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# **RCRA Facility Investigation Phase 2 Work Plan Dow Hanging Rock Plant, Ironton, Ohio**

Prepared for  
**The Dow Chemical Company**

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**CH2MHILL®**

# Executive Summary

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This Resource Conservation and Recovery Act facility investigation (RFI) work plan describes the approach and procedures for the Phase 2 RFI investigation at The Dow Chemical Company Hanging Rock Facility in Ironton, Ohio. This work plan describes the approach for additional investigations based on the findings of the Phase 1 investigation (CH2M HILL 2012). The primary objective is to satisfy the U.S. Environmental Protective Agency (USEPA) requirement under Section II.F.2 RFI of the Part B permit "...to thoroughly evaluate the nature and extent of the release of hazardous waste(s) and hazardous constituent(s) from all applicable SWMUs [solid waste management units] and AOCs [areas of concern] identified in Section II.C."

The Phase 1 RFI was conducted from December 2011 to January 2012, in accordance with the *RFI Work Plan* (CH2M HILL 2011a), as approved by USEPA on November 18, 2011. The first phase of the RFI was designed to 1) develop a basic physical conceptual site model for the site, including the general hydrogeology, and 2) investigate potential releases to soil and sediment at the specific SWMUs and AOCs at the facility. The second phase of the RFI is intended to complete delineation of the nature and extent of contamination identified during Phase 1 in soil, to evaluate groundwater for the presence of COPCs and provide the data for the human health risk assessment.

In the Phase 1 investigation, soil or sediment containing constituents at concentrations exceeding the conservative soil screening levels (SSLs) considered to be protective of groundwater were observed at SWMU 1, SWMU 15, SWMU 17, SWMU 24, SWMU 25-28, and AOC D. The Phase 2 RFI investigation will focus on these sites plus SWMU 36 and SWMU 37 because these areas were not included in the previous field investigation. Data quality objectives for the Phase 2 RFI have been developed to determine whether the constituents of potential concern identified based on the SSLs are present in groundwater at concentrations which could pose an unacceptable risk to human or ecological receptors and to determine the nature and extent of soil contamination in SWMU 24.

# Contents

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<b>Executive Summary.....</b>	<b>iii</b>
<b>Acronyms and Abbreviations .....</b>	<b>vii</b>
<b>1 Introduction .....</b>	<b>1-1</b>
1.1 Introduction and Objectives .....	1-1
1.2 Regulatory Framework and Background .....	1-1
1.3 Summary of Phase 1 RFI .....	1-1
1.3.1 SWMU 1: Former Flaring Pad .....	1-2
1.3.2 SWMU 15: Two Section Septic Tank System.....	1-2
1.3.3 SWMU 17: Stormwater Drainage System .....	1-2
1.3.4 SWMU 24: Process Sewer Line.....	1-3
1.3.5 SWMU 25-28: Former Wastewater Treatment System.....	1-3
1.3.6 SWMU 36: Former 250-gallon Pressurized Storage Tanks .....	1-3
1.3.7 SWMU 37: Fire Protection Collection Basin .....	1-4
1.3.8 AOC D: Underground Catalyst Storage Tank .....	1-4
1.3.9 Site Hydrology .....	1-4
1.4 Phase 1 RFI Conclusions .....	1-5
<b>2 Phase 2 RFI Areas .....</b>	<b>2-1</b>
2.1 Groundwater Investigations.....	2-2
2.1.1 Sampling Existing Monitoring Wells .....	2-2
2.1.2 Groundwater Grab Sampling .....	2-3
2.2 SWMU 24 Investigations .....	2-3
<b>3 Investigation Procedures.....</b>	<b>3-1</b>
3.1 RFI Field Investigations.....	3-1
3.1.1 Vertical Aquifer Sampling .....	3-1
3.1.2 Monitoring Well Sampling .....	3-1
3.1.3 MIP Investigation.....	3-2
3.1.4 Soil Sampling .....	3-2
3.1.5 Groundwater Grab Sampling .....	3-2
3.1.6 Soil Boring Documentation.....	3-3
3.1.7 Soil Boring Advancement .....	3-3
3.1.8 Water Level Measurements .....	3-3
3.1.9 Utility Clearance.....	3-3
3.1.10 Sample Identification.....	3-3
3.2 Field Quality Control.....	3-4
3.3 Equipment Decontamination.....	3-5
3.4 Investigation-Derived Waste .....	3-5
3.5 Data Validation.....	3-5
3.6 Data Evaluation .....	3-7
<b>4 Human Health Risk Assessment Approach .....</b>	<b>4-1</b>
4.1 Data Evaluation and Identification of COPCs .....	4-1
4.1.1 Selection of Constituents of Potential Concern.....	4-2
4.2 Exposure Assessment .....	4-3

4.3	Quantification of Exposure .....	4-4
4.3.1	Exposure Point Concentrations .....	4-4
4.3.2	Estimation of Chemical Intakes for Individual Pathways .....	4-5
4.3.3	Toxicity Assessment .....	4-5
4.3.4	Risk Characterization .....	4-6
4.3.5	Uncertainty Assessment .....	4-7
5	<b>Reporting</b> .....	<b>5-1</b>
6	<b>References</b> .....	<b>6-1</b>

## **Appendix**

### **A Standard Operating Procedures**

#### **Tables**

2-1	Phase 2 RFI Data Quality Objective Summary
2-2	Focused Target Analyte List for Soil and Groundwater
3-1	Proposed Sampling Locations, Types, and Analysis
4-1	Summary of Reasonable Maximum Exposure Parameters for Surface Soil Exposure Pathways
4-2	Summary of Reasonable Maximum Exposure Parameters for Soil (Combined Surface Soil and Subsurface Soil) Exposure Pathways
4-3	Summary of Reasonable Maximum Exposure Parameters for Groundwater Exposure Pathways
4-4	Summary of Reasonable Maximum Exposure Parameters for Groundwater-to-Air Exposure Pathways

#### **Figures**

1-1	Site Location
1-2	Site Layout
1-3	Cross Section Location
1-4	Cross Section A-A'
1-5	Potentiometric Surface Map
2-1	Proposed Groundwater Sample Locations
2-2	SWMU 24 – Proposed Investigation
2-3	Decision Matrix – Groundwater
2-4	Decision Matrix – Soil

# Acronyms and Abbreviations

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°C	degrees Celsius
μS/cm	microSiemens per centimeter
AF	attenuation factor
AOC	area of concern
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
CEM	conceptual exposure model
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	constituent of potential concern
CPT	cone penetrometer test
CSF	cancer slope factor
DO	dissolved oxygen
DOT	Department of Transportation
Dow	The Dow Chemical Company
DPT	direct push technology
DQO	data quality objective
ECD	electron capture detector
Eco-SSL	ecological soil screening level
ELCR	excess lifetime cancer risk
EPC	exposure point concentration
ERA	ecological risk assessment
facility	The Dow Chemical Company Hanging Rock Facility in Ironton, Ohio
FID	flame ionization detector
HDPE	high-density polyethylene
HEAST	Health Effects Assessment Summary Tables
HHRA	human health risk assessment
HI	hazard index

HQ	hazard quotient
ID	identification
IDW	investigation-derived waste
IRIS	Integrated Risk Information System
kg	kilogram
mg	milligram
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
mg/L	milligram per liter
MIP	membrane interface probe
mL/min	milliliter per minute
MS	matrix spike
MSD	matrix spike duplicate
mV	millivolt
NCEA	National Center for Environmental Assessment
NTU	nephelometric turbidity unit
Ohio EPA	Ohio Environmental Protection Agency
ORP	oxidation-reduction potential
OUPS	Ohio Underground Protective Services
PID	photoionization detector
PPRTV	provisional peer-reviewed toxicity values
PR	preliminary review
QA	quality assurance
QAPP	Quality Assurance Project Plan (
QC	quality control
RAGS	<i>Risk Assessment Guidance for Superfund</i>
RCRA	Resource Conservation and Recovery Act
RfC	reference concentration
RfD	reference dose
RFI	Resource Conservation and Recovery Act facility investigation

RME	reasonable maximum exposure
RSL	regional screening level
SLERA	screening-level ecological risk assessment
SLHHRA	screening level human health risk assessment
SOP	standard operating procedure
SSL	soil screening level
SVOC	semivolatile organic compound
SWMU	solid waste management unit
UCL	upper confidence limit
URF	unit risk factor
USEPA	United States Environmental Protective Agency
VISL	vapor intrusion screening level
VOC	volatile organic compound
VSI	visual site inspection

# Introduction

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## 1.1 Introduction and Objectives

This Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) work plan is being submitted pursuant to Section II.F.2.c of the RCRA permit OHD 039 128 913 and describes the approach and procedures for the Phase 2 RFI to be performed at The Dow Chemical Company (Dow) Hanging Rock Facility in Ironton, Ohio (facility) (Figure 1-1). Implementation of this work plan will provide the data necessary to complete delineation of the nature and extent of contamination identified during Phase 1 in soil, to evaluate groundwater for the presence of constituents of potential concern (COPCs) and provide the data for the human health risk assessment (HHRA).

The primary objective of the RFI is to “...thoroughly evaluate the nature and extent of the release of hazardous waste(s) and hazardous constituent(s) from all applicable SWMUs [solid waste management units] and AOCs [areas of concern] identified in Section II.C” as required under Section II.F.2 RFI of the permit. In order to meet the primary objective, data quality objectives (DQOs) were developed and are presented in this work plan.

## 1.2 Regulatory Framework and Background

The facility submitted a RCRA Part A permit application in 1980 and was issued an Ohio Hazardous Waste Facility Installation and Operation Permit in 1981 (A.T. Kearney 1989). This permit was modified in 1986 to include a hazardous waste storage tank. In 1989, Dow applied for a RCRA permit modification to include an additional storage process using containers. A preliminary review (PR)/visual site inspection (VSI) was conducted on behalf of the U.S. Environmental Protection Agency (USEPA) in 1989 (A.T. Kearney 1989), and a follow-up investigation was completed in 2000 (Tetra Tech 2000).

In 2005, USEPA issued an RCRA permit for the facility. Subsequent negotiations between Dow and USEPA were resolved, and a revised permit was issued in August 2010. The investigation discussed in this work plan is in accordance with the requirements of the RCRA permit.

## 1.3 Summary of Phase 1 RFI

The first phase of investigation was completed in January 2012 focused on SWMU 1, SWMU 11, SWMU 12, SWMU 15, SWMU 17, SWMU 18, SWMU 19, SWMU 24, SWMU 25-28, SWMU 29, and AOC D that were identified in the RCRA permit as requiring additional investigations (Figure 1-2). The investigation included soil and sediment data collection as well as a HHRA and ecological risk assessment (ERA) evaluation. The details of the samples collected at each area during the Phase 1 RFI are presented in the *Phase 1 RFI Report* (CH2M HILL 2012).



The following sections describe the Phase 1 RFI results and discusses the SWMUs and AOC that the need further investigation the Phase 2 RFI. Details of the Phase 2 RFI are discussed in Section 2 of this work plan. The Phase 1 RFI soil data were screened against USEPA industrial regional screening levels (RSLs) for chemical constituents in soil for human health screening levels and USEPA ecological soil screening levels (Eco-SSLs), and/or USEPA Region 5 RCRA ecological screening levels for soil and sediment for ecological screening levels. Data also were compared to USEPA soil screening levels (SSLs) that are protective of migration to groundwater. All samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and RCRA metals. Further details of the human health and ecological screening levels and calculations used for the protection of groundwater SSLs are presented in the *Phase 1 RFI Report* (CH2M HILL 2012).

### **1.3.1 SWMU 1: Former Flaring Pad**

The former flaring pad contained byproducts from Styrofoam processes containing styrene, partially polymerized polystyrene, and ethylbenzene that were then burned on the flaring pad. During the Phase 1 RFI, nine borings were advanced at SWMU 1 around the former flaring pad location. The types of subsurface materials observed included asphalt cover, silts and clayey silts, silty sand, and gravelly sand. Thirty-two soil samples were collected for analysis during the Phase 1 RFI.

VOCs were not detected above human health or ecological screening levels but tetrachloroethene exceeded protection of groundwater SSLs at three borings and trichloroethene exceeded SSLs at one boring. In addition, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, benzene, 1,1-biphenyl, and selenium exceeded protection of groundwater SSLs at SWMU 1.

### **1.3.2 SWMU 15: Two Section Septic Tank System**

This unit has been in operation since 1957 and has received septic wastewater and process wastewater from plant operations. Four borings were advanced to at least 10 feet below ground surface (bgs) at SWMU 15 around the septic tank and a former sewer line. The soil types that were encountered during drilling activities consisted of clayey silts and silty sand. From the four borings, 15 soil samples were collected for analysis during the Phase 1 RFI.

No VOCs exceeded human health or ecological screening levels. Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and mercury exceeded human health RSLs and protection of groundwater SSLs. Additional exceedances of the protection of groundwater SSLs included selenium and benzene.

### **1.3.3 SWMU 17: Stormwater Drainage System**

Stormwater runoff from the Styron, Styrofoam, and Ethafoam plants and the tank farm flows through this drainage system. Three borings were advanced to at least 10 feet bgs at SWMU 17. The soil types that were encountered during drilling activities consisted of silts and gravelly sand. Twelve soil samples and one sediment sample were collected for analysis during the Phase 1 RFI.

No soil VOCs or SVOCs exceeded the human health RSL screening levels in the samples collected during the Phase 1 RFI. Chromium and selenium exceeded ecological screening levels and nitrobenzene exceeded migration to groundwater SSLs.

No sediment VOCs exceeded human health or ecological screening levels. Pentachlorophenol exceeded ecological screening levels and protection of groundwater SSLs. Acenaphthylene and selenium exceeded protection of groundwater SSLs.

### 1.3.4 SWMU 24: Process Sewer Line

The system receives discharges from most onsite sumps, including forklift wash water, cooling tower and boiler blowdown. Water from SWMU 24 discharges to the onsite wastewater treatment plant.

Previous soil investigations and soil removal actions at SWMU 24 were completed based on VOC detections and impacts in soil. In 1996, a 150-foot length of sewer line located in the southwestern portion of the unit was voluntarily investigated, excavated, and removed as part of the closure plan for the former drum storage area and is known as the Process Sewer Line Voluntary Closure Excavation Area. The area was restored and backfilled with clean soil, demonstrating compliance with industrial and residential soil cleanup standards (CH2M HILL 2012).

During the Phase 1 RFI, eight borings were advanced to at least 10 feet bgs at SWMU 24 around the process sewer line. The soil types that were encountered during drilling activities consist of asphalt and gravel cover, silts and clayey silts underlain by gravelly sand. Twenty-seven soil samples were collected for analysis during the Phase 1 RFI.

Ethylbenzene, 1,1-biphenyl, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene were detected at concentrations exceeding human health RSLs from the samples collected during the Phase 1 RFI. These analytes also exceeded the protection of groundwater SSLs except for benzo(a)pyrene. Additional exceedances of the protection of groundwater SSLs included 1,3,5-trimethylbenzene, benzene, isopropylbenzene, n-propylbenzene, m,p- and o-xylene, and styrene.

### 1.3.5 SWMU 25-28: Former Wastewater Treatment System

The former wastewater treatment system consisted of an aerator, clarifier, chlorinator, and two tertiary sand filters. Four borings were advanced to at least 10 feet bgs at SWMU 25-28 around the former wastewater treatment system. The soil types that were encountered during drilling activities consisted of gravelly sand and clayey silt.

No VOCs exceeded the screening levels. 1,1-Biphenyl, benzo(a)pyrene, benzo(a)anthracene, and benzo(b)fluoranthene exceeded one or more screening levels in the southern borings.

### 1.3.6 SWMU 36: Former 250-gallon Pressurized Storage Tanks

Twenty 250-gallon pressurized storage tanks were located throughout the facility that were used to store liquid wastes such as solvents, oils, or liquid process wastes. The tanks were discontinued in 1995. The tanks had cradles built into them in order to move them with forklifts. No other information is available for these units. Because the tanks were moved around the Styron plant, and cannot be represented by specific locations, this SWMU was not investigated during the Phase 1 RFI and will be generally evaluated in the Phase 2 RFI by sampling sitewide groundwater.

### 1.3.7 SWMU 37: Fire Protection Collection Basin

This unit consists of a 250,000-gallon-capacity concrete basin located north of the wastewater treatment system. The unit, which began operation in 1992, primarily receives stormwater. It is constructed of concrete with high-density polyethylene (HDPE) lining the outer wall of the concrete. Joints are provided with an HDPE water-stop, and all inlet and exit piping was extrusion welded to the HDPE liner. The concrete basin is intact and competent (CH2M HILL 2011a). Given the nature of the basin's use and design, no soil investigation was performed during the Phase 1 RFI. Potential impacts from this site will be evaluated by sampling sitewide groundwater during the Phase 2 RFI.

### 1.3.8 AOC D: Underground Catalyst Storage Tank

A former 10,000-gallon steel storage tank housed in an underground concrete vault in the Styron plant was used to store the catalyst 1,1-di(tert-butylperoxy)cyclohexane, an organic peroxide. Two borings were advanced below 10 feet bgs at AOC D around the former catalyst storage tank location. The soil types that were encountered during drilling activities consist of concrete, sand, clay/silt, and gravelly sand. Eight soil samples were collected for analysis during the Phase 1 RFI.

No VOCs or SVOCs were detected in excess of human health or ecological RSLs from the samples collected during the Phase 1 RFI. Benzene exceeded the protection of groundwater SSLs.

### 1.3.9 Site Hydrology

Seven monitoring wells were installed and borings at selected locations were advanced to bedrock across the facility to provide an understanding of the facility stratigraphy, hydrogeology, and groundwater flow direction. The monitoring wells were not sampled during the Phase 1 RFI. The facility is underlain by unconsolidated material. The unconsolidated material includes surficial fill material (concrete, asphalt, silt, clay, sand, and gravel), clay, sand, and gravel. Surficial fill is observed from the surface to 0.5 to 2 feet bgs, and clay is observed near surface to depths around 10 feet bgs. The clay unit appears to be thicker in the center of the facility. Underlying the clay layer is silt that is approximately 10 feet thick and then a coarse-grained sand and gravel unit approximately 60 to 70 feet thick that generally extends to the top of shale bedrock at 80 feet bgs. A cross-section and figure showing the cross-section location were created using information from the Phase 1 RFI (Figures 1-3, 1-4).

Groundwater levels measured in January 2012 indicated the shallow groundwater direction was from northwest to southeast toward the Ohio River (Figure 1-5). Groundwater was encountered at approximately 20 feet bgs.

Regional surface water generally drains south toward the Ohio River. Ditches control most of the surface water drainage at the facility, and one drainage ditch in the northwestern portion of the facility drains to the north. SWMU 18, which receives treated water from the wastewater treatment system, flows into Big Thief Creek, which discharges to the Ohio River. The Ohio River near the facility flows from east to west.

## 1.4 Phase 1 RFI Conclusions

- Arsenic was detected in soil across the site at levels exceeding human health screening values. However, arsenic is not considered to be a constituent of concern for this facility and will not be the focus of future investigations for the following reasons:
  - Arsenic is not known to be a chemical used at the site.
  - The arsenic concentrations observed at the site ranged from 2.16 to 42.9 milligrams per kilogram (mg/kg), with the average of 11.8 mg/kg. This is consistent with a documented regional background concentration of 13 mg/kg, as presented in Appendix B: Development of Alternate Metal Standards in the *Closure Plan Review Guidance* (Ohio Environmental Protection Agency [Ohio EPA] 2009), which is located at <http://epa.ohio.gov/portals/32/pdf/2008CPRG.pdf>.
  - The risk-based screening level for arsenic is less than the background value.
- The screening level human health risk assessment (SLHHRA) determined that detected soil and sediment constituent concentrations would not pose risks above the target levels for potential exposures by human receptor populations at the facility. The screening-level ecological risk assessment (SLERA) evaluation determined that none of the site-related constituents would be considered COPCs based on risk to ecological receptors.
- The nature and extent of soil contamination at the site was delineated except for SWMU 24. Historical documentation showed the Process Sewer Line Voluntary Closure Excavation Area within SWMU 24 as being contaminated at one point in time and data collection in that area during the Phase 1 RFI confirmed contamination. Additional soil sampling will be performed around SWMU 24 during the Phase 2 RFI to determine the nature and extent of contamination in this area.
- Soil or sediment containing constituents exceeded the protection of groundwater SSLs at SWMU 1, SWMU 15, SWMU 17, SWMU 18, SWMU 24, SWMU 25-28, and AOC D. Because of the exceedances of the protection of migration to groundwater SSLs, it was concluded that site conditions will be further evaluated for these areas and additional groundwater investigation will be performed in the Phase 2 RFI.

The *Phase 1 RFI Report* was submitted to USEPA on April 16, 2012. The review process has consisted of the following:

- On August 22, 2012, USEPA submitted comments on the *Phase 1 RFI Report*.
- On October 18, 2012, Dow submitted draft responses to the comments to USEPA and a teleconference was held with USEPA, Dow, and CH2M HILL to clarify the comments.
- On January 30, 2013, a memorandum clarifying the comments was submitted by USEPA to Dow.
- On February 6, 2013, USEPA, Dow, and CH2M HILL held a teleconference to discuss this memorandum.
- On March 25, 2013, Dow submitted revised responses to comments to USEPA.

- On August 29, 2013, USEPA submitted responses to the revised responses to comments. Final approval of this document has not been received from USEPA.

## SECTION 2

# Phase 2 RFI Areas

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The primary data quality objectives of this Phase 2 RFI are to:

- Determine if site-related COPCs are present in groundwater at concentrations exceeding site-specific screening levels
- Determine the nature and extent of any site-related COPCs in groundwater that exceed conservative groundwater screening levels
- Determine the horizontal and vertical extent of soil contamination of volatile VOCs and SVOCs exceeding project-specific screening levels around the Process Sewer Line Voluntary Closure Area (SWMU 24)

The DQOs for the Phase 2 RFI are provided in Table 2-1 of the report (CH2M HILL 2012). For SWMUs and AOCs having constituents exceeding the protection of migration to groundwater screening levels in soil, the existing monitoring wells and three vertical aquifer sampling locations will be sampled to evaluate potential migration of the constituents from soil to groundwater.

For SWMU 24, where existing data are not sufficient to determine the nature and extent of constituents in soil, a membrane interface probe (MIP) investigation and additional soil confirmation samples will be collected to determine the extent of contamination near Phase 1 RFI soil sample S24-SS02 (Figure 2-2).

To provide a preliminary evaluation of overall site groundwater conditions, groundwater samples will be collected from the seven monitoring wells installed during the Phase 1 RFI. Groundwater samples also will be collected from three vertical aquifer sampling locations and up to five locations at SWMU 24 during the Phase 2 RFI. Because groundwater has not been conducted at the site and SWMU 36 and 37 are being evaluated, samples will be analyzed for the focused target analyte list (Table 2-2). This list was developed using Phase 1 RFI data and historical data from SWMU 24.

If site-related constituents in groundwater exceed site-specific screening levels at any of the SWMUs or AOC, then a risk-assessment will be completed based on the results as described in Section 4. In addition, COPCs will be identified and the plume will be evaluated to determine if the boundary has been delineated. If the plume is not delineated, additional groundwater sample locations will be proposed to determine the horizontal and vertical extent of the plume (Figure 2-3).

Because existing soil data are not sufficient to determine the nature and extent of soil contamination at SWMU 24, and because most of the COPCs associated with the SWMU 24 area are VOCs, an MIP investigation will be conducted during the Phase 2 RFI. The objective of the MIP investigation is to identify the horizontal and vertical placement of confirmation soil samples and groundwater grab samples. Up to 10 soil samples will be collected based on the MIP results and analyzed for focused target analytes (Table 2-2), and

up to five groundwater grab samples will be collected based on the MIP results and analyzed for focused target analytes (Table 2-2).

If constituents in collected soil samples exceed project-specific screening levels at SWMU 24, further evaluation of soil will be considered. Additional step-out locations from the previous contaminated soil location around SWMU 24 will be proposed to determine the vertical and lateral extent of contamination until concentrations do not exceed project-specific screening levels (Figure 2-4).

Detected groundwater concentrations will be compared to screening levels used for the sitewide groundwater investigation. Detected soil concentrations will be screened against USEPA RSLs for industrial soil screening levels for soil. Screening levels for noncancer effects will be adjusted downward by a factor of 10 to account for potential cumulative effects. Migration to groundwater SSLs will be compared to the detected concentrations. If constituents in collected soil samples do not exceed project-specific screening levels, then the constituents in the SWMU will be considered to be delineated, and no additional sampling will be performed.

## 2.1 Groundwater Investigations

The effects on groundwater from past site practices is unknown. As presented in the *Phase 1 RFI Report* (CH2M HILL 2012), soil concentrations at the following SWMUs and AOCs were above the migration to groundwater RSLs, indicating the potential for impacts to groundwater in the following areas:

- SWMU 01 (Former Flaring Pad)
- SWMU 15 (Two-Section Septic Tank System)
- SWMU 17 (Stormwater Drainage System)
- SWMU 24 (Process Sewer Line)
- SWMU 25-28 (Former Wastewater Treatment System)
- AOC D (Underground Catalyst Storage Tank)

In addition, the potential impacts to groundwater from SWMU 36 and SWMU 37, if any, are unknown. These two SWMUs will be evaluated during the sitewide groundwater investigation phase (Phase 2 RFI) to evaluate potential impacts from these SWMUs.

Groundwater samples will be analyzed for the focused target analyte list (Table 2-2). Total and dissolved metals will be collected from the existing monitoring wells and dissolved metals will be collected from the vertical profile and grab samples. The sampling activities that will be performed to evaluate sitewide groundwater include sampling the existing monitoring wells and groundwater grab samples. Details of each sampling activity are described below.

### 2.1.1 Sampling Existing Monitoring Wells

Depth to groundwater measurements and groundwater samples will be collected from the seven existing monitoring wells (MW-01 through MW-07) to investigate the potential impacts from AOC D, SWMU 36, and SWMU 37 (Figure 2-1). MW-01 is upgradient from AOC D, SWMU 36, and SWMU 37 while MW-05, MW-06 and MW-07 are downgradient from these three areas. MW-02 and MW-03 are downgradient from AOC D while MW-04 is

downgradient from SMWU 36 and SWMU 37. These existing monitoring wells will help determine the nature and extent of groundwater contamination and COPCs.

### 2.1.2 Groundwater Grab Sampling

Groundwater grab samples will be collected at three locations across the site and at SWMU 24. Vertical aquifer sampling will be performed at three locations to evaluate potential groundwater impacts related to SWMU 1, SWMU 15, SWMU 17, and SWMU 25-28 (Figure 2-1). The vertical profile samples will be collected at three different intervals to help fill in data gaps for SWMUs not covered by the existing wells. The soil data from the Phase 1 RFI were used to determine the locations of the three vertical aquifer profiles with the rationale discussed below:

- **VP-08**-Evaluate groundwater downgradient of a portion of SWMU 17 and SWMU 25-28
- **VP-09**-Evaluate groundwater downgradient of SWMU 15 and a portion of SWMU 17
- **VP-10**-Evaluate groundwater downgradient of SWMU 1 and SWMU 17

The three profiles will provide additional stratigraphic data for the portion of the aquifer between the water table and bedrock. Additional groundwater grab samples will be collected from one interval up to five locations from SWMU 24 based on the MIP investigation. Further details of the MIP investigation are described in Section 2.2.

## 2.2 SWMU 24 Investigations

VOCs and SVOCs have exceeded the USEPA industrial RSLs in soil in the SWMU 24 area; however, the extent of the VOCs and SVOCs has not been determined.

During the Phase 1 RFI, 27 soil samples from eight borings across SWMU 24 were collected and analyzed for VOCs, SVOCs, and metals. VOCs and SVOCs in one boring (S24-SS02) exceeded USEPA SSLs at 13 to 15 feet bgs. Soil data collected for this DQO will support the horizontal and vertical delineation extents of soil contamination of VOCs and SVOCs exceeding project-specific screening levels around SWMU 24 in the area near soil boring S24-SS02.

The Phase 2 RFI at SWMU 24 is focused on approximately 230 feet of sewer line that is centered on the Process Sewer Line Voluntary Closure Excavation Area near soil boring S24-SS02 (Figure 2-2). Based on historical data and the Phase 1 RFI results, this is the only area of SWMU 24 that requires additional delineation. Figure 2-2 shows the proposed locations for the MIP investigation along this portion of SWMU 24, which will delineate the extent of VOCs in the soil. If the MIP results show concentrations of VOCs above screening levels at the proposed locations, step-out locations will be sampled with the MIP to determine the estimated extent of soil contamination. Following completion of the MIP investigation, up to ten soil confirmation samples and up to five groundwater samples will be collected to confirm the MIP data, based on the real-time readings from the investigations. Agreement will be obtained from USEPA on confirmation locations before any soil or groundwater samples are collected. The soil will be logged and boring logs will be developed to identify soil types within SWMU 24.

Soil samples will be analyzed for VOCs and SVOCs from the focused target analyte list (Table 2-2).



# Investigation Procedures

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## 3.1 RFI Field Investigations

This section presents sampling activities that will be performed. The work will be completed in accordance with procedures described below.

### 3.1.1 Vertical Aquifer Sampling

Vertical aquifer sampling will be performed at three locations as shown on Figure 2-1. Profiles will be drilled using direct push technology (DPT) and groundwater grab samples will be collected every 20 feet from the top of the water table (approximately 20 feet bgs) to bedrock (approximately 80 feet bgs). Groundwater grab samples will be according to the standard operating procedure (SOP), *Direct-Push Groundwater Grab Sample Collection* (Appendix A). These samples will be submitted to Lancaster Laboratories for analysis of the focused target analyte list (Table 2-2).

### 3.1.2 Monitoring Well Sampling

The existing monitoring wells were installed during the Phase 1 RFI. Before sampling, the depth to water will be measured in the seven wells (Figure 2-1). The wells will be sampled using low-flow techniques described in the SOP, *Low-flow Groundwater Sampling* (Appendix A). The pump inlet will be set at the middle of the saturated interval in the screens since the entire screen is not under the water table. Samples analyzed for dissolved metals will be filtered in the field before going to the laboratory for analysis.

At least two system volumes will be purged and parameter stabilization achieved before collecting groundwater samples. The system volume includes the volume of the discharge tubing, pump, and flow-through cell. The SOP specifies parameter stabilization as the following:

- Dissolved oxygen (DO):  $\pm 0.1$  milligram per liter (mg/L) for values less than 1 mg/L, or 10 percent for values greater than 1 mg/L.
- Eh (oxidation-reduction potential [ORP]):  $\pm 10$  millivolts (mV).
- Specific conductance:  $\pm 1$  percent of full-scale reading (instrument repeatability) or default  $\pm 50$  microSiemens per centimeter ( $\mu\text{S}/\text{cm}$ ).
- pH:  $\pm 0.1$  unit.
- Temperature:  $\pm 0.5$  degrees Celsius ( $^{\circ}\text{C}$ ).
- Turbidity is considered stabilized if values are less than 20 nephelometric turbidity units (NTUs) for three successive readings at 5-minute intervals (assuming a 100 milliliters per minute [mL/min] flow rate).

- Groundwater samples will be collected in accordance with the SOP, *Low-flow Groundwater Sampling* (Appendix A). The samples will be submitted to Lancaster Laboratories for analysis of the focused target analyte list (Table 2-2).

### 3.1.3 MIP Investigation

The MIP is a downhole screening tool that is used to identify VOCs in soil and groundwater. The MIP provides a qualitative VOC relative concentration data; however, it does not identify specific VOC compounds and it does not quantify concentrations. It will be used as a screening tool to identify VOC-bearing intervals for targeted soil or groundwater sampling.

The MIP tool will be advanced using a DPT or cone penetrometer test (CPT) rig and allows for rapid, real-time soil logging and constituent screening of subsurface soil and groundwater. The tool heats the soil and groundwater immediately adjacent to the probe to approximately 120°C, which increases volatilization of VOCs present in the media. Vapors produced during the heating process diffuse across a semipermeable membrane in the tip of the probe tool and into a closed, inert gas loop tubing system that carries the vapors to a series of detectors housed at the surface. The sensors provide continuous profiles of qualitative VOC relative concentration data for the entire depth of the borehole. The detectors that will be used are a photoionization detector (PID), an electron capture detector (ECD), and a flame ionization detector (FID). The PID is useful for identifying aromatic VOCs; the FID will identify most VOCs with a hydrogen carbon bond (including most aromatic VOCs and other petroleum compounds). The ECD is useful for detecting most chlorinated VOCs.

The MIP also measures soil conductivity, which indicates general changes in lithology. In general, higher conductivities indicate finer-grained material such as clay or silt, while lower conductivities indicate coarser-grained materials such as sand and gravel. Changes in the conductivity will be assessed against the known lithology of the area to evaluate general depths of lithology changes.

### 3.1.4 Soil Sampling

Soil borings will be advanced to a depth based on the MIP investigation using DPT. The interval of the soil sample will be determined based on where the MIP results shows potential elevated VOC concentrations. At SWMU 24, up to 10 locations will be determined and soil samples will be collected using the DPT sampling procedures described in the SOP, *Direct-Push Technology Soil Sample Collection* (Appendix A). Equipment will be decontaminated according to the SOP, *Field Sampling Equipment Decontamination* (Appendix A). The samples will be sent to Lancaster Laboratories for analysis of VOCs and SVOCs in the focused target analyte list (Table 2-2).

### 3.1.5 Groundwater Grab Sampling

Based on the MIP investigation at SWMU 24, groundwater grab samples will be collected at up to five boring locations using standard DPT sampling methods and the groundwater samples will be collected using a stainless steel foot valve. Groundwater will be purged from the sampling interval according to the SOP, *Direct-Push Groundwater Grab Sample Collection* (Appendix A). Groundwater grab samples will be collected from the foot valve and analyzed for the focused target analyte list (Table 2-2). Samples will be filtered in the

field for dissolved metals analyses. The samples will be submitted to Lancaster Laboratories for analysis.

### 3.1.6 Soil Boring Documentation

To ensure a detailed description of subsurface conditions, soil samples from borings and monitoring wells will be collected continuously. Soil samples will be logged using the Unified Soil Classification System in accordance with American Society for Testing and Materials D2488 (visual-manual method for field description). The boring log will include observations on soil type, grain size distribution, changes in lithology, stained soil or chemical odor, soil moisture, PID reading, depth to the water table, depth intervals of samples collected for laboratory analysis, and total depth of boring (see SOP, *Soil Boring Logging*, in Appendix A).

### 3.1.7 Soil Boring Advancement

Soil borings will be abandoned in accordance with applicable Ohio requirements. A bentonite-cement slurry or hydrated bentonite chips will be placed from the bottom to the top of the hole using a tremie pipe or by hand. Abandoned soil borings will be checked 24 hours after abandonment to ensure curing occurred properly. If settling has occurred, solid bentonite will be added to fill the hole to the ground surface.

### 3.1.8 Water Level Measurements

Depth to water and depth to bottom measurements will be collected from the existing monitoring wells within a 24-hour period. The depth to water measurements will be used to calculate groundwater elevations, which will be used to evaluate groundwater flow.

### 3.1.9 Utility Clearance

Before drilling each location, the utilities at each soil boring location will be cleared by Ohio Underground Protective Services (OUPS). The facility will be notified before any drilling, and a representative will consult any available facility drawings. In addition, a private utility locator will be contracted to locate buried utilities at the DPT soil boring and monitoring well locations.

### 3.1.10 Sample Identification

CH2M HILL has devised a sample numbering system that will be used to identify each sample, including duplicates and blanks. The method of sample identification (ID) used depends on the type of sample collected and the sample container type. The field analysis data will be recorded in bound field logbooks or recorded on data sheets along with sample identity information while in the custody of the sampling team.

Labels for samples sent to a laboratory for analysis will be written in indelible ink. The following information is typically included on the sample label:

- Site name or identifier
- Sample ID number
- Date and time of sample collection
- Sample matrix or matrix identifier (SS=surface soil, SB=soil boring, SD=sediment)
- Type of analyses to be conducted

Each analytical sample will be assigned a unique number as described below.

**Soil is as follows: S01-SS01-XXXX-12DD11**

Where:

A or S=AOC or SWMU sample is taken from (ACD=AOC D, S01=SWMU 1)  
SS = Soil  
GW = Groundwater Grab Samples  
MW= Monitoring Well Samples  
VP=Vertical Profile Samples  
XXXX = Sample Depth (for monitoring wells, the top of the screened interval)  
12DD11 = Month, day and year sample was collected  
FD = Field Duplicate  
EB=Equipment blank  
TB = Trip Blank  
MS/MSD=Matrix Spike/Matrix Spike Duplicate

Examples:

- Duplicates will be blind. The duplicates will be numbered consecutively when more than one duplicate is collected in a day. The first field duplicate collected on April 25, 2011, would be **HGR- 042511-FD01**.
- A sample collected at SWMU 01 at location 05 from 8 to 9 feet on April 25, 2012, would be **S01-SS05-0809-042511**.
- A matrix spike (MS)/matrix spike duplicate (MSD) sample collected at location 05 from 8 to 9 feet bgs on April 25, 2011, would be **S01-SS05-0809-042511MS/MSD**.
- A trip blank will be collected each day samples are collected and shipped. A trip blank collected on April 25, 2011, would be labeled 042511TB.

The sample ID numbers will be tracked electronically from collection through laboratory analysis and into the final reports. The sample number will be checked to make sure it matches with is entered on the chain-of-custody form.

## 3.2 Field Quality Control

A description of the field QC samples and the frequency of collection are provided below. Field QC samples will include the following:

- Trip blank: Samples used to monitor potential VOC contamination introduced during sample shipping and handling. One trip blank will be included with each cooler containing samples for VOC analysis (aqueous and solid phase).
- Equipment rinsate blanks: Samples of American Society for Testing and Materials Type II water passed through and over the surface of decontaminated sampling equipment. One equipment rinsate blank will be collected for every 20 field samples or per event if less than 20 samples collected.

- Temperature blanks: Shipped with each cooler to the offsite laboratory containing samples requiring preservation at approximately 4 degrees Celsius. The temperature blanks are not to be analyzed for analytical parameters. One temperature blank will be shipped with each cooler.
- Field duplicates: Samples collected to monitor the precision of the field sampling process. One field duplicate will be collected for every 10 field samples (per matrix) or per event if less than 10 samples collected (per matrix).
- MS/MSD: Spike recovery is used to evaluate potential matrix interferences, as well as accuracy. The duplicate spike results (MS and MSD) are compared to evaluate precision. One MS/MSD sample set will be collected for every 20 field samples or per event if less than 20 samples collected.

### 3.3 Equipment Decontamination

Sampling equipment that is reused in the field will be decontaminated in accordance with the procedures described in the SOP, *Field Sampling Equipment Decontamination* (Appendix A). Excess media and decontamination materials and liquids will be disposed of in accordance with the procedures described in Section 3.5. A decontamination pad will be constructed at a location designated by the facility.

### 3.4 Investigation-Derived Waste

The generation of three types of investigation-derived waste (IDW) is anticipated during this investigation: liquid, soil, and solid. Liquid IDW consisting of decontamination fluids and purge water will be containerized in U.S. Department of Transportation (DOT)-approved 55-gallon steel drums.

Soil IDW consisting of soil removed from the soil borings during DPT activities will be containerized in DOT-approved 55-gallon drums. Each IDW drum will be staged as directed by Dow and will be identified with a “PENDING ANALYSIS” label. The label will indicate the location, depth intervals contained, and the date the waste was generated.

Solid IDW consisting of personal protective equipment, sampling expendables (e.g., tubing, liners, etc.), plastic, and related consumable material will be contained in trash bags and disposed of in an approved dumpster designated by Dow and the site safety coordinator.

The first two categories of IDW will be characterized for disposal at the end of this phase of the project or within 45 days of the date of generation, and will be transported and disposed of by a Dow-approved contractor following proper characterization.

### 3.5 Data Validation

Data review, verification, and validation are the processes by which data, generated in support of a project, are reviewed against the data quality assurance (QA)/quality control (QC) requirements. The data are evaluated for precision and accuracy against the analytical protocol requirements. Nonconformance or deficiencies that could affect the precision or accuracy of the reported result are identified and noted. The effect on the result then is considered when assessing whether the result is sufficient to achieve DQOs.

All data collected as part of this investigation will be consistent with the Quality Assurance Project Plan (QAPP) (CH2M HILL 2011b) and will be validated by CH2M HILL.

Deficiencies discovered as a result of data verification, review, or validation, as well as corrective actions implemented in response, will be documented and submitted in the form of a written report.

Personnel involved in the data validation function will be independent of any data generation effort. The project chemist will be responsible for oversight of the data validation effort. Data validation will be carried out when the data packages are received from the laboratory. It will be performed on an analytical batch basis using the summary results of calibration and laboratory QC, as well as those of the associated field samples. Raw data will be reviewed when deemed necessary by the project chemist. Data validation procedures will include the following:

- Review of the data package for completeness
- Review of chain-of-custody records for discrepancies that might degrade data quality
- Review for compliance with holding time and QC frequency requirements
- Evaluation of all calibration and QC summary results against the project requirements
- Qualification of the data using appropriate qualifier flags, as necessary, to reflect data usability limitations
- Initiation of corrective actions, as necessary, based on the data review findings

It is important to note that laboratory qualifying flags are included on the data summary forms that are submitted to the project by the laboratory; however, during the data review and validation process, the laboratory qualifying flags are reviewed along with the project-specific validation flags to determine the final project qualifier applied to the data. Data qualifier flags, if required, will be applied to the electronic sample results. If multiple flags are required for a result, the most severe flag will be applied to the electronic result. The hierarchy of flags from the most severe to the least severe will be as follows: R, J, UJ, and U. The definition of each qualifier flag are indicated below:

- J - Analyte was present but reported value may not be accurate or precise.
- R - This result has been rejected.
- U - This analyte was analyzed for but not detected at the specified detection limit.
- UJ -The analyte was not detected above the detection limit objective. However, the reported detection limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample

Data from the RFI sampling events will be evaluated for quality with respect to reporting limits and laboratory qualifiers. During the data evaluation step, the following procedures will be used:

- Rejected ("R" qualified) data will be excluded from the risk assessment.

- A value reported as estimated (“J” qualified) will be included in the risk assessment if it is the only value provided for a sample, or if it is the highest reported result from a set of reported values from dilutions and/or reanalysis, given these two conditions.
- For duplicate samples, the maximum concentration between the two samples will be used as the sample concentration.

## 3.6 Data Evaluation

Surface soil, subsurface soil, and groundwater analytical results will be screened against the project- specific screening levels discussed in Section 2. Data obtained in this phase will be used to identify COPCs and determine the nature and extent of impacts.

The Phase 2 RFI boring logs generated will be used to refine understanding of site stratigraphy. The monitoring well gauging data will be used to develop a potentiometric surface map. This information will be used to evaluate groundwater flow relative to the SWMUs and AOC being investigated in the Phase 2 RFI. This information along with the analytical data and MIP data will be used to evaluate nature and extent and create an updated site conceptual model.

HHRA interim deliverables also will be included in the report. The HHRA is discussed in more detail in Section 4 and will be used along with the nature and extent delineation to determine the need for and scope of future investigation phases.

## SECTION 4

# Human Health Risk Assessment Approach

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An SLHHRA was performed using the Phase 1 RFI data (CH2M HILL 2012) to evaluate potential risks associated with exposure to soil and sediment by potential current and future receptor populations. The Phase 1 RFI SLHHRA followed the methodology described in the USEPA-approved work plan (CH2M HILL 2011a). The SLHHRA determined that detected surface soil (0-to-2 foot bgs interval), total soil (0-to-10 foot bgs interval), and sediment concentrations at evaluated SWMUs and AOCs do not pose risks above the USEPA risk management levels (target cancer risk of  $1 \times 10^{-6}$  to  $1 \times 10^{-4}$  and target noncancer hazard index [HI] of 1) to potential receptor populations under industrial land use. As noted in Section 2, the Phase 2 RFI will include soil sampling to delineate the nature and extent of soil contamination at SWMU 24 and sitewide groundwater data will be collected. The HHRA will focus on SWMU 24 soil data, combining Phase 1 RFI and Phase 2 RFI data into one dataset, and Phase 2 RFI groundwater data planned for collection (Section 2.7) RFI to conduct a baseline HHRA.

The HHRA will provide an evaluation of the potential current and future risks to human health posed by detected constituents at the site in accordance with USEPA guidance for conducting HHRA. The overall approach for the HHRA will follow USEPA *Risk Assessment Guidance for Superfund, Part A, Volume 1 (RAGS)* and associated guidance documents (USEPA 1989, 1990, 1991).

The risk assessment consists of the following components:

- **Data Evaluation and Identification of COPCs**—identification of the constituents found onsite and selection of the COPCs. COPCs identified in this screening are the focus of the subsequent evaluation in the risk assessment.
- **Exposure Assessment**—identification of the potential pathways of human exposure, characterization of the potentially exposed populations, and estimation of the magnitude, frequency, and duration of exposures.
- **Toxicity Assessment**—assessment of the potential adverse effects of the COPCs and compilation of the toxicity values used for developing numerical risk estimates.
- **Risk Characterization**—integration of the results of the exposure assessment and toxicity assessment to develop numerical estimates of health risks.
- **Uncertainty Assessment**—identification and discussion of sources of uncertainty associated with the data, methodology, and values used in the risk assessment.

## 4.1 Data Evaluation and Identification of COPCs

Soil and groundwater samples will be addressed in the SLHHRA as follows:

- Soil data collected from SWMU 24 as part of the Phase 2 RFI will be combined with soil data collected during the Phase 1 RFI investigation in December 2011 and January 2012



to evaluate the complete SWMU 24 dataset for applicable current and future soil exposure scenarios for the HHRA.

- Groundwater samples collected during the Phase 2 RFI will be used to evaluate applicable current and future groundwater exposure scenarios.
- The following bullets discuss how the qualified data will be evaluated in the risk assessment:
  - Rejected (“R” qualified) data will be excluded from the risk screening.
  - Estimated (“J” qualified) data will be treated as detected concentrations in the risk screening.
  - For duplicate samples, the higher concentration of the two samples will be used as the sample concentration.

The methodology that will be used in the preliminary COPC screening assessment is consistent with that described in the USEPA-approved work plan (CH2M HILL 2011a). Soil samples collected from discrete depths between 0 and 10 feet bgs at SWMU 24 during Phases 1 and 2 will be evaluated. Surface soil samples collected from 0 to 2 feet bgs will be used to evaluate the current/future industrial scenario and current/future trespasser scenario and future maintenance worker scenario. Because future invasive activities may disturb soil in the shallow subsurface (0 to 10 feet bgs) and bring current subsurface soil to the ground surface where contact may occur, soil from the total soil will be used to evaluate reasonable current/future routine worker and future construction worker and future maintenance worker exposure scenarios.

#### 4.1.1 Selection of Constituents of Potential Concern

The COPC screening process will be conducted for soil at SWMU 24; groundwater will be screened on a sitewide or site-specific basis, as appropriate, based on results of groundwater sampling. The maximum detected concentration of each detected constituent will be compared to its screening level. If the maximum detected concentration exceeds its screening level, it will be retained as a COPC for further evaluation in the HHRA. If a detected constituent in a medium does not have an appropriate screening level, then it will be compared to the screening level for a surrogate chemical, if available. Constituents that are nondetected in all samples within an environmental medium will not be selected as COPCs. The COPC selection process will be presented in RAGS Part D Table 2 (USEPA 2001).

Risk-based screening levels for medium that are based on the constituent-specific noncancer effects will be reduced by a factor of 10 (i.e., adjusted to a hazard quotient [HQ] = 0.1) to account for the potential presence of multiple constituents affecting the same target organ, while no adjustment will be made for the risk-based screening levels that are based on carcinogenic health endpoints (i.e., the screening levels will be based on a target excess lifetime cancer risk [ELCR] of  $1 \times 10^{-6}$ ). For those constituents with more than one risk-based screening level (e.g., carcinogenic-based level and noncarcinogenic-based level [HQ = 0.1]), the lowest value will be selected as the final risk-based screening level for that constituent. The maximum detected concentration of each constituent in each medium will be compared to the criteria discussed below to select the COPCs for the medium.

- **Surface Soil:** The maximum detected surface soil concentration of each constituent was compared to the USEPA industrial soil RSLs (USEPA 2013a).
- **Groundwater:** Groundwater data for detected constituents will be compared to the tap water RSLs (USEPA 2013a).
- **Vapor Intrusion from Groundwater to Indoor Air:** Groundwater vapor intrusion screening levels (VISLs) protective of the vapor intrusion exposure pathways for onsite industrial land use (USEPA 2013b) that will be used in the evaluation to identify COPCs are based on:
  - May 2013 USEPA VISLs for Industrial Indoor Air (USEPA 2013b)
  - Default source soil gas (i.e., at the top of the groundwater table) to the indoor air attenuation factor (AF) of 0.001 (USEPA 2002)
  - An average sitewide groundwater temperature (degrees Celsius) to correct chemical-specific Henry's Law Constants for groundwater VISLs protective of indoor air.

## 4.2 Exposure Assessment

Exposure refers to the potential contact of an individual with a constituent. The exposure assessment identifies pathways and routes by which an individual may be exposed to the COPCs, and estimates the magnitude, frequency, and duration of potential exposure. Constituent intakes and associated health risks are only quantified for complete exposure pathways.

The human health conceptual exposure model (CEM) presented in the Phase 1 RFI SLHHRA (CH2M HILL 2012) provides an overview of site conditions, potential contaminant migration pathways, and exposure pathways to potential receptors. As additional site use and conditions information is gathered throughout the investigations, the CEM will be refined and presented in the Phase 2 RFI report with a discussion of the basis of refinements.

As described in the Phase 1 RFI SLHHRA, current potentially complete exposure pathways and scenarios related to the facility include:

- Trespassers (onsite): Exposure to surface soil (0- to 2-foot bgs interval) through incidental ingestion, dermal contact, and inhalation of particulate and volatile emissions
- Routine workers (onsite): Exposure to surface soil (0- to 10-foot bgs interval) through incidental ingestion, dermal contact, and inhalation of particulate and volatile emissions outdoors and inhalation of volatile emissions from subsurface vapor intrusion into indoor air

Based on the objectives of the Phase 1 RFI (CH2M HILL 2012), analytical data were not collected from groundwater monitoring wells. Therefore, the Phase 1 RFI SLHHRA did not quantitatively address potential groundwater exposure pathways.

Groundwater at the facility was encountered at approximately 20 feet bgs in the monitoring wells installed during the Phase 1 RFI investigation; therefore, subsurface contact with groundwater may not be a potentially complete exposure pathway. If further investigation

of groundwater during the Phase 2 RFI indicates groundwater is encountered within 10 feet of the surface (depth intervals typical of construction and utility maintenance activities), then the following potential exposures to groundwater for will be included in the evaluation:

- Future construction workers (onsite): Exposure to shallow groundwater through dermal contact. Exposure to combined surface soil and subsurface soil (0- to 10-foot bgs interval) during construction activities through incidental ingestion, dermal contact, and inhalation of particulate and volatile emissions will be evaluated as part of the cumulative receptor assessment.
- Future maintenance workers: (onsite): Exposure to shallow groundwater through dermal contact. Exposure to surface soil (0- to 2-foot bgs interval) during utilities repair and maintenance through incidental ingestion, dermal contact, and inhalation of particulate and volatile emissions will be evaluated as part of the cumulative receptor assessment.

## 4.3 Quantification of Exposure

Exposure is quantified by estimating the exposure point concentrations (EPC) and chemical intakes by the receptors for the reasonable maximum exposure (RME) scenario.

### 4.3.1 Exposure Point Concentrations

EPCs are estimated chemical concentrations that a receptor may come in contact with and are specific to each exposure medium. EPCs may be directly measured or estimated using environmental transport models.

The samples that will be evaluated in the risk assessment will be summarized and presented in the risk assessment, along with the data groupings used to calculate the EPCs for each SWMU and AOC. The EPCs will be calculated in accordance with USEPA guidance (USEPA 2002). The EPCs will be calculated as the 95 percent upper confidence limit (UCL) of the arithmetic mean concentration as described below. The maximum detected concentration will be used as the EPC in cases where the estimated 95 percent UCL is greater than the maximum detected concentration.

ProUCL software Version 4.1.00 (USEPA 2011) will be used to determine the distribution that the data fit and to calculate the 95 percent UCLs. ProUCL includes three possible data distribution tests: normal distribution, log-normal distribution, and gamma distribution. The UCL calculation method then is selected based on the data distribution (i.e., normal, lognormal, gamma, or nonparametric if the data do not fit any of the distributions). The recommendations outlined in the ProUCL software documentation will be followed to select the appropriate UCL (USEPA 2011). ProUCL output for each medium-specific constituent EPC will be presented in an appendix.

The groundwater data exposure groupings will be selected in a manner consistent with groundwater characterization. If groundwater is contiguous sitewide and constituent concentrations do not indicate localized plumes, then groundwater will be evaluated on a sitewide basis. Otherwise, groundwater will be evaluated for each individual SWMU and AOC.

### 4.3.2 Estimation of Chemical Intakes for Individual Pathways

Intake is the amount of a constituent entering the exposed receptor's body. Intakes of COPCs through contact with exposure media, such as incidental ingestion and dermal contact with soil, are expressed using algorithms provided in USEPA guidance (USEPA 1989, 2004). The generalized equation for calculating chemical intakes is as follows:

$$I (mg/kg - day) = \frac{C \times CR \times EF \times ED}{BW \times AT}$$

Where:

- I = intake (milligrams per kilogram per day [mg/kg-day])
- C = chemical concentration at exposure point (the EPC; mg/L or mg/kg)
- CR = contact rate, or amount of contaminated medium contacted per unit time or event (liters per day or milligrams [mg] per event)
- EF = exposure frequency (days per year)
- ED = exposure duration (years)
- BW = body weight of exposed individual (kilograms [kg])
- AT = averaging time, or period over which exposure is averaged (days)

The algorithms for estimating intakes of COPCs for individual exposure pathways are provided in Tables 4-1 through 4-4 with a summary of the exposure factors that will be used for each exposure scenario at the site.

### 4.3.3 Toxicity Assessment

Toxicity assessment defines the relationship between the magnitude of exposure and possible severity of adverse effects, and weighs the quality of available toxicological evidence. USEPA recommends that a tiered approach be used to obtain the toxicity values (reference doses [RfDs] and cancer slope factors [CSFs]) that are used to calculate noncarcinogenic hazards and carcinogenic risks, respectively (USEPA 2003). The sources of toxicity values were: (1) Integrated Risk Information System (IRIS), (2) provisional peer-reviewed toxicity values (PPRTV), and (3) other USEPA and non-USEPA sources including the National Center for Environmental Assessment (NCEA), Agency for Toxic Substances and Disease Registry (ATSDR), Health Effects Assessment Summary Tables (HEAST), California Environmental Protection Agency, and USEPA's Office of Water.

#### Toxicity Information for Noncarcinogenic Effects

Noncarcinogenic effects are quantified by comparing exposure or intake to either RfDs or inhalation reference concentrations (RfCs). Chronic RfDs and RfCs, which are developed to evaluate potential toxicity for long-term exposure (more than 7 years of exposure). Subchronic RfDs and RfCs are sometimes used to evaluate exposures of durations ranging from 2 weeks to 7 years, which may be more appropriate to address childhood (1 to 6 years) and construction worker (less than 1 year) exposure durations. Subchronic values are generally less available from data sources than other types of toxicity information. In the absence of an acceptable subchronic toxicity value, chronic values will be used conservatively in the HHRA to evaluate exposure pathways.

## Toxicity Information for Carcinogenic Effects

Potential carcinogenic effects are quantified using oral CSFs and inhalation unit risk factors (URFs). For carcinogens, risks are estimated as the probability that an individual will develop cancer over a lifetime because of exposure to the carcinogen. Cancer risk from exposure to contamination represents the anticipated excess or incremental cancer risk, which is cancer occurrence in addition to normally expected rates of cancer development over the average adult lifetime of 70 years.

### 4.3.4 Risk Characterization

Risk characterization combines the results of the previous elements of the risk assessment to evaluate the potential health risks associated with exposure to the COPCs. Potential human health risks are evaluated independently for carcinogenic and noncarcinogenic constituents because of the different toxicological endpoints, relevant exposure duration, and methods used to characterize risk. Some constituents may produce both noncarcinogenic and carcinogenic effects, and will be evaluated in both groups.

Estimated noncancer hazards and potential cancer risks for the groundwater exposure pathway will be summed with estimates for the soil exposure pathways presented above to determine cumulative hazards and cancer risks across exposure pathways for each receptor population identified above. Because of the collection of analytical data only onsite, potential exposures of the offsite receptor populations will be assumed not to exceed those of the onsite receptor populations, and therefore will not be separately quantified.

The maintenance worker scenario will be evaluated using site-specific exposure assumptions consistent with activities involving repair and maintenance of subsurface utilities.

#### Estimation of Noncancer Hazards

Noncarcinogenic health risks will be estimated by comparing the calculated intake to an RfD. The calculated intake divided by the RfD is equal to the HQ:

$$\text{HQ} = \text{Intake} / \text{RfD}$$

The intake and RfD represent the same exposure period (i.e., chronic or subchronic) and the same exposure route (i.e., oral intakes are divided by oral RfDs). An HQ that exceeds 1 (i.e., the intake exceeds the RfD) indicates there is a potential for adverse health effects associated with exposure to that constituent.

To assess the potential for noncarcinogenic health effects posed by exposure to multiple constituents, an HI approach will be calculated by summing all HQs (USEPA 1986). HIs also are added across exposure routes and media to estimate the total noncarcinogenic health effects to a receptor posed by exposure through multiple routes and media. If the HI is greater than 1, separate HIs will be estimated for each target organ to assess whether the HI for a specific target organ is greater than 1. A target organ-specific HI greater than 1 indicates there is some potential for adverse noncarcinogenic health effects associated with exposure to the COPCs, possibly warranting remedial action. If the HI for each target organ does not exceed 1, noncarcinogenic hazards are not expected.

### Estimation of Excess Lifetime Cancer Risks

The potential for carcinogenic effects due to exposure to site-related constituents is evaluated by estimating the ELCR. Carcinogenic risk is calculated by multiplying the intake by the CSF.

$$\text{ELCR} = \text{Intake} \times \text{CSF}$$

The combined risk from exposure to multiple constituents will be evaluated by adding the risks from individual constituents. Risks also will be added across the exposure routes and media if an individual would be exposed through multiple routes and to multiple media.

When a cumulative carcinogenic risk to an individual receptor under the assumed RME exposure conditions at a site exceeds 100 in a million (i.e.,  $10^{-4}$  excess carcinogenic risk), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) generally requires remedial action to reduce risks at that site (USEPA 1991).

#### 4.3.5 Uncertainty Assessment

The risk measures used in HHRA are not fully probabilistic estimates of risk, but are estimates based on a set of assumptions about exposure and toxicity. Thus, it is important to specify the assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective (USEPA 1989). The uncertainty section will present a discussion of the uncertainties for each of the major components of the assessment (i.e., data evaluation, exposure assessment, toxicity assessment, and risk characterization).

## SECTION 5

# Reporting

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Following the completion of field activities, an *RFI Phase 2 Report* will be prepared. This report will describe the field activities and present validated analytical data, the HHRA, a revised conceptual site model, and suggestions for the path forward.

In accordance with the RCRA permit, the *RFI Phase 2 Report* will be submitted to USEPA 90 days after completion of field activities.

## SECTION 6

# References

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## Tables

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TABLE 2-1  
Phase 2 RFI Data Quality Objectives Summary  
*Hanging Rock Facility, Ironton, Ohio*  
*The Dow Chemical Company*

DQO	Step 1—State the Problem	Step 2—Goals of the Study	Step 3—Identify Information Inputs	Step 4—Define Boundaries of the Study	Step 5—Develop the Analytical Approach	Step 6—Specify Performance or Acceptance Criteria	Step 7—Develop the Plan for Obtaining Data
1	<p>The effects on groundwater from past site practices is unknown. As presented in the Phase I Investigation Report, soil concentrations at the following solid waste management units (SWMUs) and areas of concern (AOCs) were above the conservative groundwater soil screening levels (SSLs), indicating the potential for impacts to groundwater in the areas of:</p> <ul style="list-style-type: none"><li>• SWMU 01 (Former Flaring Pad)</li><li>• SWMU 15 (Two-Section Septic Tank System)</li><li>• SWMU 17 (Stormwater Drainage System)</li><li>• SWMU 24 (Process Sewer Line)</li><li>• SWMU 25-28 (Former Wastewater Treatment System)</li><li>• AOC D (Underground Catalyst Storage Tank)</li></ul> <p>In addition, the potential impacts to site-wide groundwater from SWMU 36 and SWMU 37 are unknown.</p>	<p>Determine that site-related constituents of potential concern (COPCs) present in groundwater are below site specific screening levels.</p> <p>Determine the nature and extent of COPCs in groundwater that exceed conservative groundwater screening levels.</p>	<p>Groundwater elevations and potentiometric surface data.</p> <p>Groundwater analytical data from the seven site monitoring wells, as well as data from the three vertical aquifer locations.</p> <p>Groundwater data from up to five locations at SWMU 24.</p> <p>Project-specific screening levels as follows: maximum contaminant levels (MCLs); USEPA tap water regional screening levels (RSLs); and USEPA groundwater industrial vapor intrusion screening levels (VISLs) for human health will be used as risk-based concentrations for screening. USEPA tap water RSLs and USEPA industrial groundwater VISLs for noncancer effects will be adjusted downward by a factor of 10 to account for potential cumulative effects from multiple chemicals.</p>	<p>The study area will be bound horizontally by the monitoring well network and vertically by the vertical profile locations.</p> <p>Figure 1 shows the locations of each SWMU and AOC, as well as the locations of existing monitoring wells MW-01 through MW-07.</p> <p>The existing monitoring wells (MW-01 through MW-07) will be sampled in order to investigate potential impacts from AOC D, SWMU 36, and SWMU 37.</p> <p>Vertical aquifer sampling will be performed at three locations, as shown in Figure 1. Groundwater grab samples will be collected every 20 feet from the top of the water table (approximately 20 feet below ground surface [bgs]) to bedrock (approximately 80 feet bgs) The soil data in the Phase I Report was used to determine the locations of the three vertical groundwater locations. The rational of the sample locations is discussed below:</p> <p>VP-08-Evaluate groundwater downgradient of SWMU 17 and SWMU 25-28.</p> <p>VP-09-Evaluate groundwater downgradient of SWMU 15 and SWMU 17.</p> <p>VP-10-Evaluate groundwater downgradient of SWMU 1 and SWMU 17.</p> <p>Up to five groundwater samples will be collected from SWMU 24 at locations and depths to be determined based on the results of the Membrane Interface Probe (MIP) investigation (see DQO 2).</p>	<p>If site related constituents in groundwater do not exceed project-specific screening levels, then no further action is necessary relative to groundwater.</p> <p>If site related constituents in groundwater exceed project-specific screening levels, then a preliminary risk-assessment will be completed. In addition, the plume will be evaluated to determine if it has been delineated. If not, additional groundwater sampling will be considered.</p>	<p>Data will be used to determine if there are COPCs in groundwater that pose a risk to human health and the environment.</p> <p>The use of the seven existing monitoring wells, three vertical borings for groundwater collection downgradient of selected SWMUs, and up to five groundwater samples from SWMU 24 is expected to adequately represent the groundwater at the site and be sufficient for use in the risk assessments.</p> <p>The horizontal or vertical extent of potential COPCs in groundwater may not be adequately delineated. In accordance with the phased investigation approach, additional groundwater delineation may be necessary.</p> <p>Analytical protocols will provide the necessary data to meet method and project specification for precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS).</p> <p>Analytical methods will provide the lowest available detection limits to allow the data to meet the project-specific action levels.</p>	<p>Seven existing monitoring wells, three new vertical aquifer sampling locations, and up to five locations at SWMU 24 will be sampled (Figure 1). Based on the results of the Phase 1 soil sampling and a review of waste streams at the facility, analytical parameters for all groundwater samples will be the focused target analyte list of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and metals to assess potential contaminant concentrations (Table 2-2).</p> <p>Water levels will be measured at the existing monitoring wells to further evaluate groundwater flow direction.</p> <p>The sampling design is streamlined and intended to provide information on potential impacts to groundwater.</p> <p>Additional sampling may be warranted if contamination in groundwater is identified at concentrations in excess of the project action levels and further delineation is determined to be needed.</p> <p>Obtain stakeholder consensus for any additional investigation or path forward.</p>

TABLE 2-1  
Phase 2 RFI Data Quality Objectives Summary  
*Hanging Rock Facility, Ironton, Ohio*  
*The Dow Chemical Company*

DQO	Step 1—State the Problem	Step 2—Goals of the Study	Step 3—Identify Information Inputs	Step 4—Define Boundaries of the Study	Step 5—Develop the Analytical Approach	Step 6—Specify Performance or Acceptance Criteria	Step 7—Develop the Plan for Obtaining Data
2	<p>Existing soil data is not sufficient to determine the nature and extent of soil contamination in SWMU 24. Previous soil investigations and soil removal actions at SWMU 24 were completed based on VOC contamination. Soil sampling was conducted at SWMU 24 during the Phase 1 investigation. VOC and SVOCs in one boring (S24-SS02) exceeded USEPA soil screening levels (SSLs) at 13-15 feet bgs. The vertical and lateral extent of soil contamination is not known. Additional soil investigation is required to determine the extent of contamination at SWMU 24 in the area around S24-SS02.</p> <p>Potential impact to groundwater will be evaluated as part of DQO 1.</p>	<p>Determine the horizontal and vertical extent of soil contamination of VOCs and SVOCs exceeding project-specific screening levels around the Process Sewer Line Voluntary Closure Area (near soil boring location S24-SS02).</p>	<p>Historical soil analytical data.</p> <p>Screening level data from MIP will be used to delineate the extent of VOCs in soil. Up to 10 soil confirmation samples will be collected to confirm the MIP data.</p> <p>VOC/SVOC soil analytical data from this investigation.</p> <p>Project-specific screening level objectives: USEPA RSLs for industrial soil will be compared to detected concentrations; screening levels for noncancer effects will be adjusted downward by a factor of 10 to account for potential cumulative effects. Migration to groundwater SSLs will be compared to the detected concentrations.</p> <p>Boring logs to identify the soil types.</p>	<p>The area is defined by the portion of SWMU 24 that is centered on the Process Sewer Line Voluntary Closure Excavation Area (approximately 230 feet of sewer near soil boring S24-SS02), as shown on Figure 2.</p>	<p>If constituents in collected soil samples do not exceed project specific screening levels, then the constituents in the SWMU will be considered to be delineated and no additional sampling will be performed.</p> <p>If constituents in collected soil samples exceed project-specific screening levels, further evaluation of soil will be considered.</p>	<p>MIP will be used to determine the horizontal and vertical placement of confirmation soil samples.</p> <p>Soil data will be used to make a yes/no decision on complete delineation by comparing the maximum detected concentration to the project-specific, risk-based screening levels. In this situation, a statistical hypothesis test is not being performed and; therefore, it is not necessary to specify limits on making a wrong decision.</p> <p>Analytical data will provide the necessary data to meet method and project specification for PARCCS.</p> <p>Analytical methods will provide the lowest available detection limits to allow the data to meet the project-specific screening objectives.</p>	<p>MIP will be used to determine the location of confirmation soil borings. Up to 10 borings will be advanced using direct-push technology (DPT) methods at a subset of the MIP/cone penetration test (CPT) borings for the purposes of collecting soil and groundwater grab samples to confirm the MIP/CPT data. Up to 10 soil samples will be collected at intervals determined by the MIP. The collected soil samples will be analyzed for VOCs and SVOCs from the focused target analyte list (Table 2-2).</p> <p>As discussed in DQO 1, five groundwater samples will also be collected as determined by the MIP.</p> <p>Additional sampling may be warranted if contamination is identified at concentrations in excess of the project actions levels and further delineation of SWMU 24 is needed.</p> <p>Obtain stakeholder consensus for any additional investigation or path forward.</p>

TABLE 2-2

Focused Target Analyte List for Soil and Groundwater\*

*Hanging Rock Facility, Ironton, Ohio**The Dow Chemical Company*

Analyte
<b>VOCs</b>
Acrylonitrile
1,2,4 Trichlorobenzene
1,3,5-Trimethylbenzene
Benzene
Bromoform
Ethylbenzene
Isopropylbenzene
m+p-Xylene
Methylene Chloride
Napthalene
n-Propylbenzene
o-Xylene
Styrene
Tetrachloroethene
Trichloroethene
<b>SVOCs</b>
1,1'-Biphenyl
2-Methylnaphthalene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Dibenz(a,h)anthracene
Dibenzofuran
Indeno(1,2,3-cd)pyrene
Nitrobenzene
Pentachlorophenol
<b>METALS</b>
Arsenic
Chromium
Mercury
Selenium

**Notes:**

\*Focused target analytes are constituents with soil concentrations exceeding either protection to groundwater soil screening levels (identified as groundwater medium) or industrial soil direct contact regional screening levels (identified as soil medium) or both or chemicals of potential concern based on historic data review.

Soil samples will be analyzed for just the focused target analyte VOCs and SVOCs.  
Groundwater samples will be analyzed for the complete list.

TABLE 3-1

Proposed Sampling Locations, Types and Analysis

*Hanging Rock Facility, Ironton, Ohio**The Dow Chemical Company*

<b>SWMU</b>	<b>Description</b>	<b>Sample Location</b>	<b>Samples to Collect</b>	<b>Number of Samples</b>	<b>Proposed Analytes</b>
1	Former Flaring Pad	VP-10	Groundwater grab	4	Focused Target Analyte List
15	Two-Section Septic Tank System	VP-09	Groundwater grab	4	Focused Target Analyte List
17	Storm Water Drainage System	VP-08, VP-09, VP-10	Groundwater grab	12	Focused Target Analyte List
24	Process Sewer Line	TBD based on MIP	Groundwater grab	5	Focused Target Analyte List
24	Process Sewer Line	TBD based on MIP	Soil	10	Focused Target Analyte List (VOCs and SVOCs only)
25-28	Former Wastewater Treatment System	VP-08	Groundwater grab	4	Focused Target Analyte List
36	Former 250-gallon Pressurized Storage Tanks	MW-01 through MW-07	Groundwater	7	Focused Target Analyte List
37	Fire Protection Collection Basin	MW-01 through MW-07	Groundwater	7	Focused Target Analyte List
<b>AOC</b>	<b>Description</b>	<b>Sample Location</b>	<b>Samples to Collect</b>	<b>Number of Samples</b>	<b>Proposed Analytes</b>
D	Underground Catalyst Storage Tank	MW-01 through MW-07	Groundwater	7	Focused Target Analyte List

**Notes:**

TBD = To Be Determined

MIP = Membrane Interface Probe

VOC = volatile organic compound

SVOC = semivolatile organic compound

Focused Target Analyte List = A select list of VOCs, SVOCs and metals. See Table 2-2 for details.

TABLE 4-1

Summary of Reasonable Maximum Exposure Parameters for Surface Soil Exposure Pathways

Hanging Rock Facility, Ironton, Ohio

The Dow Chemical Company

Scenario Timeframe: Current/Future

Medium: Surface Soil

Exposure Medium: Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Trespasser	Adult	Surface Soil	CS	Chemical Concentration in Soil	Site-Specific	mg/kg	Site-Specific	Chronic Daily Intake (CDI) (mg/kg-day) = CS x IR-S x EF x ED x CF x 1/BW x 1/AT
				IR-S	Ingestion Rate of Soil	100	mg/day	USEPA, 1991	
				EF	Exposure Frequency	52	days/year	(1)	
				ED	Exposure Duration	24	years	USEPA, 1991	
				CF	Conversion Factor 1	0.000001	kg/mg	--	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	
		Adolescent	Surface Soil	CS	Chemical Concentration in Soil	Site-Specific	mg/kg	Site-Specific	Chronic Daily Intake (CDI) (mg/kg-day) = CS x IR-S x EF x ED x CF x 1/BW x 1/AT
				IR-S	Ingestion Rate of Soil	100	mg/day	USEPA, 1991	
				EF	Exposure Frequency	52	days/year	(1)	
				ED	Exposure Duration	9	years	(2)	
				CF	Conversion Factor 1	0.000001	kg/mg	--	
				BW	Body Weight	51	kg	USEPA, 1997, (3)	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	USEPA, 1989	
		Child	Surface Soil	CS	Chemical Concentration in Soil	Site-Specific	mg/kg	Site-Specific	Chronic Daily Intake (CDI) (mg/kg-day) = CS x IR-S x EF x ED x CF x 1/BW x 1/AT
				IR-S	Ingestion Rate of Soil	200	mg/day	USEPA, 1991	
				EF	Exposure Frequency	52	days/year	(1)	
				ED	Exposure Duration	6	years	USEPA, 1991	
				CF	Conversion Factor 1	0.000001	kg/mg	--	
				BW	Body Weight	15	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	USEPA, 1989	
	Maintenance Worker (Future only)	Adult	Surface Soil	CS	Chemical Concentration in Soil	Site-Specific	mg/kg	Site-Specific	Chronic Daily Intake (CDI) (mg/kg-day) = CS x IR-S x EF x ED x CF x 1/BW x 1/AT
				IR-S	Ingestion Rate of Soil	100	mg/day	USEPA, 1991	
				EF	Exposure Frequency	52	days/year	(4)	
				ED	Exposure Duration	25	years	USEPA, 1991	
				CF	Conversion Factor	0.000001	kg/mg	--	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	USEPA, 1989	

TABLE 4-1

Summary of Reasonable Maximum Exposure Parameters for Surface Soil Exposure Pathways

Hanging Rock Facility, Ironton, Ohio

The Dow Chemical Company

Scenario Timeframe: Current/Future

Medium: Surface Soil

Exposure Medium: Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Trespasser	Adult	Surface Soil	CS	Chemical Concentration in Soil	Site-Specific	mg/kg	Site-Specific	$CDI \text{ (mg/kg-day)} =$ $CS \times SA \times SSAF \times DABS \times CF \times EF \times$ $ED \times 1/BW \times 1/AT$
				SA	Skin Surface Area Available for Contact	5,700	cm <sup>2</sup>	USEPA, 2004	
				SSAF	Surface Soil to Skin Adherence Factor	0.07	mg/cm <sup>2</sup> -day	USEPA, 2004	
				DABS	Dermal Absorption Factor Solids	Chemical-Specific	--	USEPA, 2004	
				CF	Conversion Factor 1	0.000001	kg/mg	--	
				EF	Exposure Frequency	52	days/year	(1)	
				ED	Exposure Duration	24	years	USEPA, 1991	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	
	Trespasser	Adolescent	Surface Soil	CS	Chemical Concentration in Soil	Site-Specific	mg/kg	Site-Specific	$CDI \text{ (mg/kg-day)} =$ $CS \times SA \times SSAF \times DABS \times CF \times EF \times$ $ED \times 1/BW \times 1/AT$
				SA	Skin Surface Area Available for Contact	3,800	cm <sup>2</sup>	USEPA, 2004, (5)	
				SSAF	Surface Soil to Skin Adherence Factor	0.3	mg/cm <sup>2</sup> -day	USEPA, 2004, (6)	
				DABS	Dermal Absorption Factor Solids	Chemical-Specific	--	USEPA, 2004	
				CF	Conversion Factor 1	0.000001	kg/mg	--	
				EF	Exposure Frequency	52	days/year	(1)	
				ED	Exposure Duration	9	years	(2)	
				BW	Body Weight	51	kg	USEPA, 1997, (3)	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	USEPA, 1989	
		Child	Surface Soil	CS	Chemical Concentration in Soil	Site-Specific	mg/kg	Site-Specific	$CDI \text{ (mg/kg-day)} =$ $CS \times SA \times SSAF \times DABS \times CF3 \times EF \times$ $ED \times 1/BW \times 1/AT$
				SA	Skin Surface Area Available for Contact	2,800	cm <sup>2</sup>	USEPA, 2004	
				SSAF	Surface Soil to Skin Adherence Factor	0.2	mg/cm <sup>2</sup>	USEPA, 2004	
				DABS	Dermal Absorption Factor Solids	Chemical-Specific	--	USEPA, 2004	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				EF	Exposure Frequency	52	days/year	(1)	
				ED	Exposure Duration	6	years	USEPA, 1991	
				BW	Body Weight	15	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	USEPA, 1989	



TABLE 4-1

Summary of Reasonable Maximum Exposure Parameters for Surface Soil Exposure Pathways

*Hanging Rock Facility, Ironton, Ohio**The Dow Chemical Company*

Scenario Timeframe: Current/Future

Medium: Surface Soil

Exposure Medium: Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
	Maintenance Worker (Future only)	Adult	Surface Soil	CS	Chemical Concentration in Soil	Site-Specific	mg/kg	Site-Specific	$CDI \text{ (mg/kg-day)} =$ $CS \times SA \times SSAF \times DABS \times CF \times EF \times$ $ED \times 1/BW \times 1/AT$
				SA	Skin Surface Area Available for Contact	3,300	cm <sup>2</sup>	USEPA, 2004, (3)	
				SSAF	Surface Soil to Skin Adherence Factor	0.3	mg/cm <sup>2</sup> -day	USEPA, 2004, (4)	
				DABS	Dermal Absorption Factor Solids	Chemical-Specific	--	USEPA, 2004	
				CF	Conversion Factor 1	0.000001	kg/mg	--	
				EF	Exposure Frequency	52	days/year	(4)	
				ED	Exposure Duration	25	years	USEPA, 1991	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	USEPA, 1989	

## Notes:

- (1) Professional judgment assuming 2 day per week for 26 weeks per year.
- (2) Professional judgment assuming adolescents from 9 to 18 years of age.
- (3) Body weight is average of the mean values for boys and girls for the ages 9 through 18.
- (4) Professional judgment assuming maintenance worker performing maintenance activities 1 day per week for 52 weeks.
- (5) Surface area includes face, forearms, hands, and lower legs for children 9-18 year old.
- (6) Surface soil-to-skin adherence factor is based on 95th percentile adherence factor for soccer players #1 (age 13-15 years).

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TABLE 4-2

Summary of Reasonable Maximum Exposure Parameters for Soil (Combined Surface Soil and Subsurface Soil) Exposure Pathways

Hanging Rock Facility, Ironton, Ohio

The Dow Chemical Company

Scenario Timeframe: Current/Future

Medium: Soil\*

Exposure Medium: Soil\*

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Routine Worker	Adult	Surface Soil	CS	Chemical Concentration in Soil	Site-Specific	mg/kg	Site-Specific	Chronic Daily Intake (CDI) (mg/kg-day) = CS x IR-S x EF x ED x CF x 1/BW x 1/AT
				IR-S	Ingestion Rate of Soil	100	mg/day	USEPA, 1991	
				EF	Exposure Frequency	250	days/year	USEPA, 1991	
				ED	Exposure Duration	25	years	USEPA, 1991	
				CF	Conversion Factor 1	0.000001	kg/mg	--	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	USEPA, 1989	
	Construction Worker (Future only)	Adult	Soil*	CS	Chemical Concentration in Soil	Site-Specific	mg/kg	Site-Specific	Chronic Daily Intake (CDI) (mg/kg-day) = CS x IR-S x EF x ED x CF x 1/BW x 1/AT
				IR-S	Ingestion Rate of Soil	330	mg/day	USEPA, 2002	
				EF	Exposure Frequency	125	days/year	(1)	
				ED	Exposure Duration	1	years	USEPA, 1991	
				CF	Conversion Factor 1	0.000001	kg/mg	--	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	
Dermal	Routine Worker	Adult	Surface Soil	CS	Chemical Concentration in Soil	Site-Specific	mg/kg	Site-Specific	CDI (mg/kg-day) = CS x SA x SSAF x DABS x CF x EF x ED x 1/BW x 1/AT
				SA	Skin Surface Area Available for Contact	3,300	cm <sup>2</sup>	USEPA, 2004	
				SSAF	Surface Soil to Skin Adherence Factor	0.2	mg/cm <sup>2</sup> -day	USEPA, 2004	
				DABS	Dermal Absorption Factor Solids	Chemical-Specific	--	USEPA, 2004	
				CF	Conversion Factor 1	0.000001	kg/mg	--	
				EF	Exposure Frequency	250	days/year	USEPA, 1991	
				ED	Exposure Duration	25	years	USEPA, 1991	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	USEPA, 1989	

TABLE 4-2

Summary of Reasonable Maximum Exposure Parameters for Soil (Combined Surface Soil and Subsurface Soil) Exposure Pathways

*Hanging Rock Facility, Ironton, Ohio**The Dow Chemical Company*

Scenario Timeframe: Current/Future

Medium: Soil\*

Exposure Medium: Soil\*

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
	Construction Worker (Future only)	Adult	Soil*	CS	Chemical Concentration in Soil	Site-Specific	mg/kg	Site-Specific	$CDI \text{ (mg/kg-day)} =$ $CS \times SA \times SSAF \times DABS \times CF \times EF \times$ $ED \times 1/BW \times 1/AT$
				SA	Skin Surface Area Available for Contact	3,300	cm <sup>2</sup>	USEPA, 2004	
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm <sup>2</sup> -day	USEPA, 2004	
				DABS	Dermal Absorption Factor Solids	Chemical-Specific	--	USEPA, 2004	
				CF	Conversion Factor 1	0.000001	kg/mg	--	
				EF	Exposure Frequency	125	days/year	(1)	
				ED	Exposure Duration	1	years	USEPA, 1991	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	

Notes:

\* Surface soil &amp; subsurface soil combined

(1) Assumed duration of construction project is 1/2 of a working year.

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

USEPA, 1991: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

USEPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment (Final). EPA/540/R/99/005. July 2004.

**TABLE 4-3**  
Summary of Reasonable Maximum Exposure Parameters for Groundwater Exposure Pathways  
*Hanging Rock Facility, Ironton, Ohio*  
*The Dow Chemical Company*

Scenario Timeframe: Future  
Medium: Groundwater (Shallow Aquifer)  
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Routine Worker	Adult	Shallow Aquifer - Tap Water	CW	Chemical Concentration in Water	Site-Specific	µg/l	Site-Specific	CDI (mg/kg-day) = CW x IR-W x EF x ED x CF x 1/BW x 1/AT
				IR-W	Ingestion Rate of Water	1	liters/day	USEPA, 1991	
				EF	Exposure Frequency	250	days/year	USEPA, 1991	
				ED	Exposure Duration	25	years	USEPA, 1991	
				CF	Conversion Factor 1	0.001	mg/µg	--	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
Dermal	Routine Worker	Adult	Shallow Aquifer - Tap Water	AT-N	Averaging Time (Non-Cancer)	9,125	days	USEPA, 1989	CDI (mg/kg-day) = DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				CW	Chemical Concentration in Water	Site-Specific	µg/l	Site-Specific	
				DA <sub>event</sub>	Dermally Absorbed Dose per Event	Calculated	mg/cm <sup>2</sup> -event	Calculated	
				t <sub>event</sub>	Event Duration	0.58	hr/event	(1)	
				SA	Skin Surface Area Available for Contact	3,300	cm <sup>2</sup>	USEPA, 2004 (2)	
				EV	Event Frequency	1	events/day	USEPA, 1991	
				EF	Exposure Frequency	250	days/year	USEPA, 1991	
				ED	Exposure Duration	25	years	USEPA, 1991	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	USEPA, 1989	
	Construction Worker	Adult	Shallow Aquifer - Water in	CW	Chemical Concentration in Water	Site-Specific	µg/l	Site-Specific	CDI (mg/kg-day) = DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm <sup>2</sup> -event	Calculated	
				FA	Fraction absorbed water	Chemical-Specific	dimensionless	USEPA, 2004	
				K <sub>p</sub>	Permeability Coefficient	Chemical-Specific	cm/hr	USEPA, 2004	
				τ	Lag Time	Chemical-Specific	hr/event	USEPA, 2004	
				t*	Time to Reach Steady-state	Chemical-Specific	hours	USEPA, 2004	
				B	Epidermis	Chemical-Specific	dimensionless	USEPA, 2004	
				t <sub>event</sub>	Event Time	8	hr/day	(3)	
				SA	Skin Surface Area Available for Contact	5,700	cm <sup>2</sup>	USEPA, 2004, (4)	
				EV	Event Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	125	days/year	(5)	
				ED	Exposure Duration	1	years	USEPA, 1991	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	
				CF1	Conversion Factor 1	0.001	mg/µg	--	
				CF2	Conversion Factor 2	0.001	l/cm <sup>3</sup>	--	

Notes:

- (1) USEPA Region 2 and the Andelman model as modified by Schaum et. al.
- (2) Skin surface area in contact with groundwater assumed to be head, hands, and forearms.
- (3) Professional judgment based on construction activities that would occur 8 hrs per day.
- (4) Skin surface area in contact with groundwater assumed to be hands, forearms, lower legs, and feet.
- (5) Assumed duration of construction project is 1/2 of a working year.

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.  
USEPA, 1991: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.  
USEPA, 2004: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

TABLE 4-4

Summary of Reasonable Maximum Exposure Parameters for Groundwater-to-Air Exposure Pathways

Hanging Rock Facility, Ironton, Ohio

The Dow Chemical Company

Scenario Timeframe: Future

Medium: Groundwater

Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/Reference	Intake Equation/ Model Name
Inhalation	Routine Worker	Adult	Shallow Aquifer - Indoor Air	CW	Chemical Concentration in Water	Site-Specific	µg/l	Site-Specific	Chronic Daily Intake (CDI) (mg/m <sup>3</sup> ) = CA x ET x ED x EF x CF1 x 1/AT CA calculated using generic attenuation factor of 0.001 and chemical-specific Henry's Law Constant value
				CA	Chemical Concentration in Air	Calculated	mg/m <sup>3</sup>	Calculated	
				EF	Exposure Frequency	250	days/year	USEPA, 1991	
				ED	Exposure Duration	25	years	USEPA, 1991	
				ET	Exposure Time	8	hr/day	USEPA, 1991	
				CF1	Conversion Factor 1	1/24	day/hour	--	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	USEPA, 1989	
	Construction Worker	Adult	Shallow Aquifer - Water Vapors in Excavation Pit	CW	Chemical Concentration in Water	Site-Specific	µg/l	Site-Specific	Chronic Daily Intake (CDI) (mg/m <sup>3</sup> ) = CA x ET x EF x ED x CF1 x 1/AT CA calculated using two-film model
				CA	Chemical Concentration in Air	Calculated	mg/m <sup>3</sup>	Calculated	
				ET	Exposure Time	8	hr/day	(1)	
				EF	Exposure Frequency	125	days/year	(2)	
				ED	Exposure Duration	1	years	USEPA, 1991	
				CF1	Conversion Factor 1	1/24	day/hour	--	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	

## Notes:

(1) Professional judgment based on construction activities that would occur 8 hrs per day.

(2) Assumed duration of construction project is 1/2 of a working year.

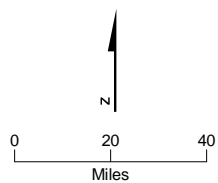
## Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

USEPA, 1991: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

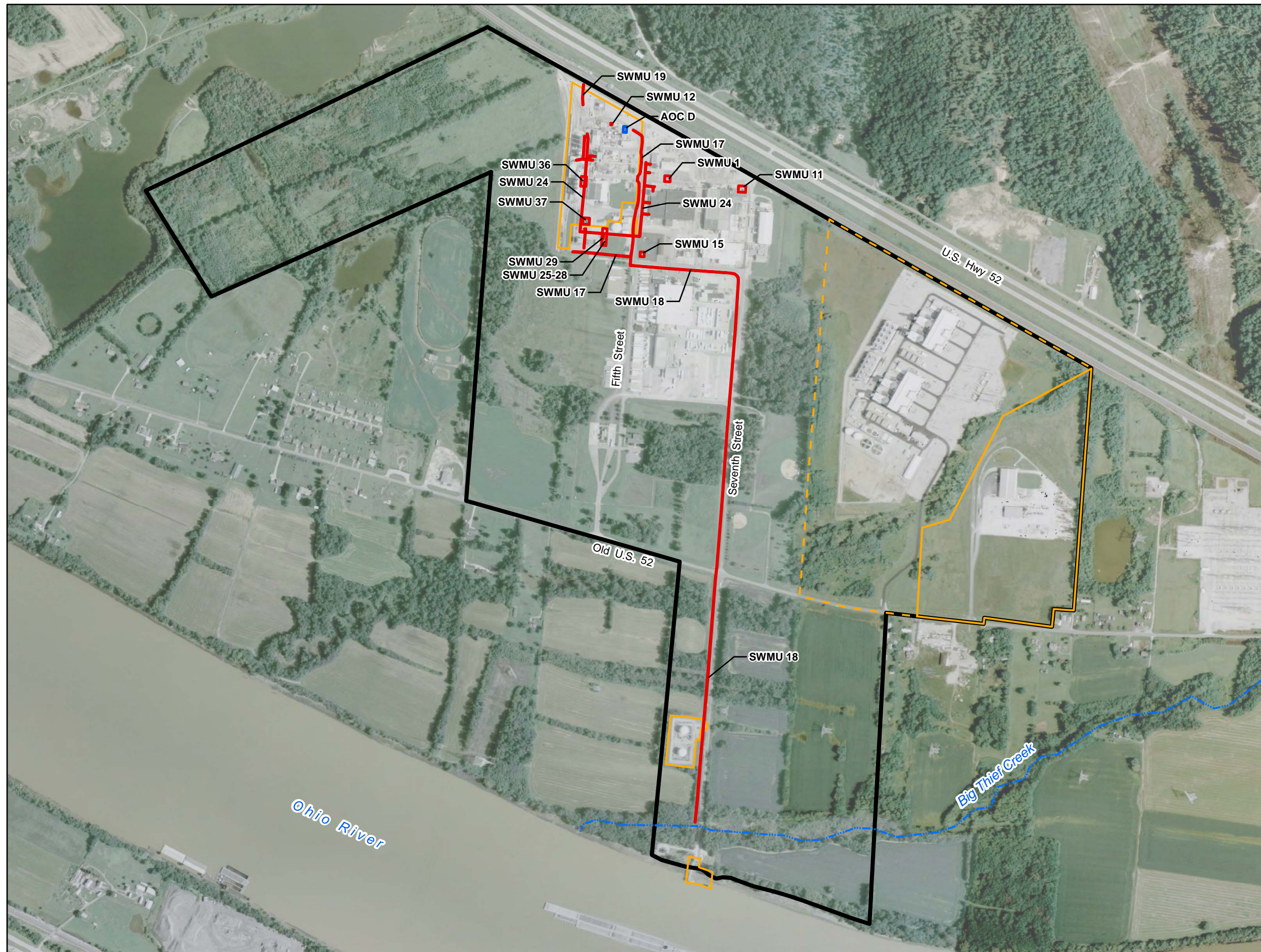
## Figures

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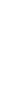


**FIGURE 1-1**  
**Site Location**  
Dow Hanging Rock Phase 2 RFI Work Plan  
Ironton, Ohio





- LEGEND**
- Approximate Site Boundary
  - Property Owned or Leased by Others (Dashed = Assumed Boundary)
  - AOC
  - SWMU
  - Big Thief Creek



**FIGURE 1-2**  
**Site Layout**  
 Dow Hanging Rock Phase 2 RFI Work  
 Plan Ironton, Ohio  
**CH2MHILL**



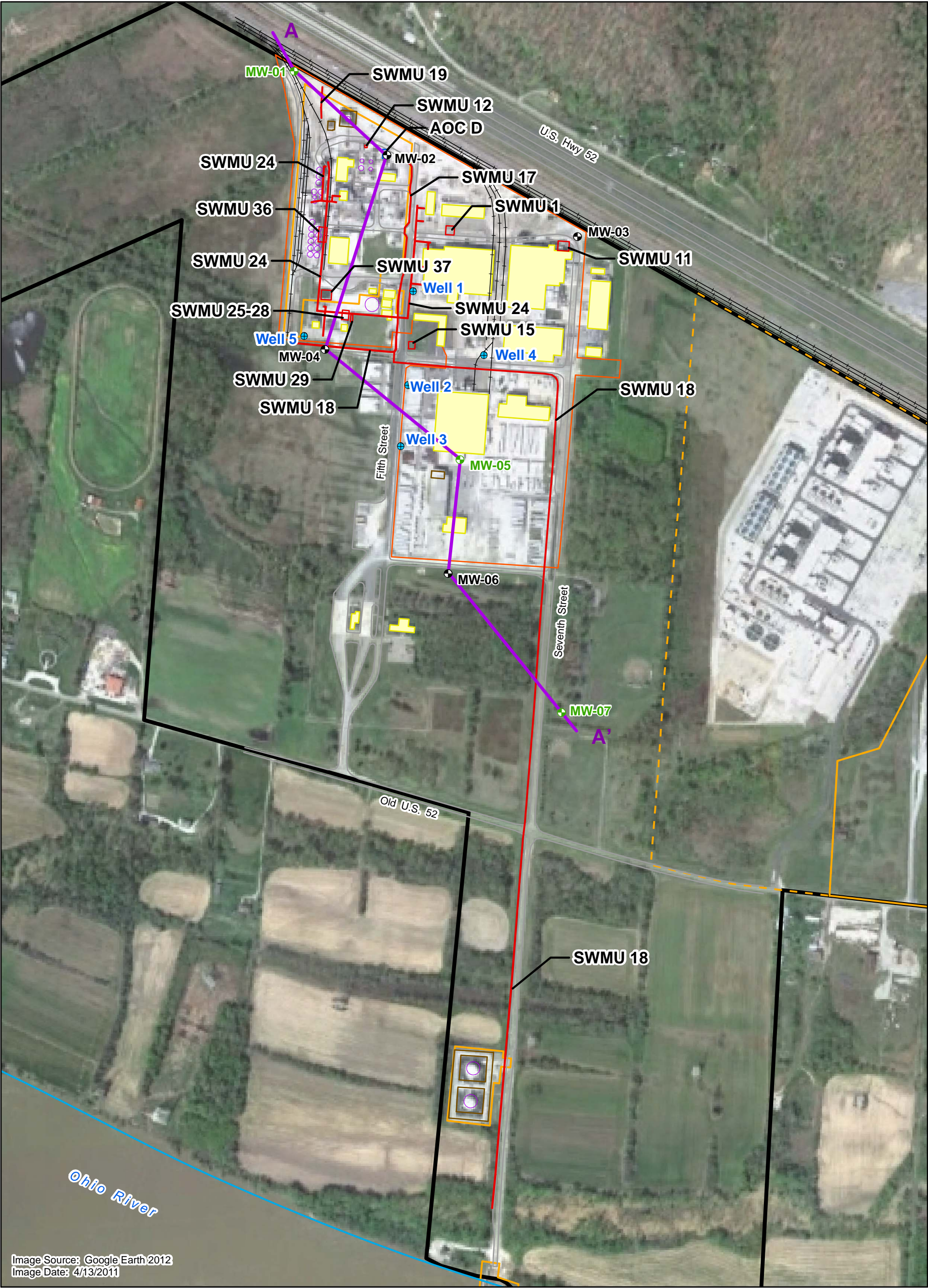
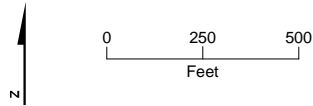


Image Source: Google Earth 2012  
Image Date: 4/13/2011

**LEGEND**

- |  |                         |                                 |
|--|-------------------------|---------------------------------|
| Approximate Site Boundary                                      | Miscellaneous Structure | Approximate Water Well Location |
| Property Owned or Leased by Others (Dashed = Assumed Boundary) | Tank                    | Monitoring Well                 |
| AOC  | Railroad                | Monitoring Well / Deep Boring   |
| SWMU   | Fence                   |                                 |
| Building   | Edge of Road            |                                 |
|  | Cross Section Location  |                                 |



**FIGURE 1-3**  
**Cross Section Location**  
Dow Hanging Rock Phase 2 RFI Work Plan  
Ironton, Ohio



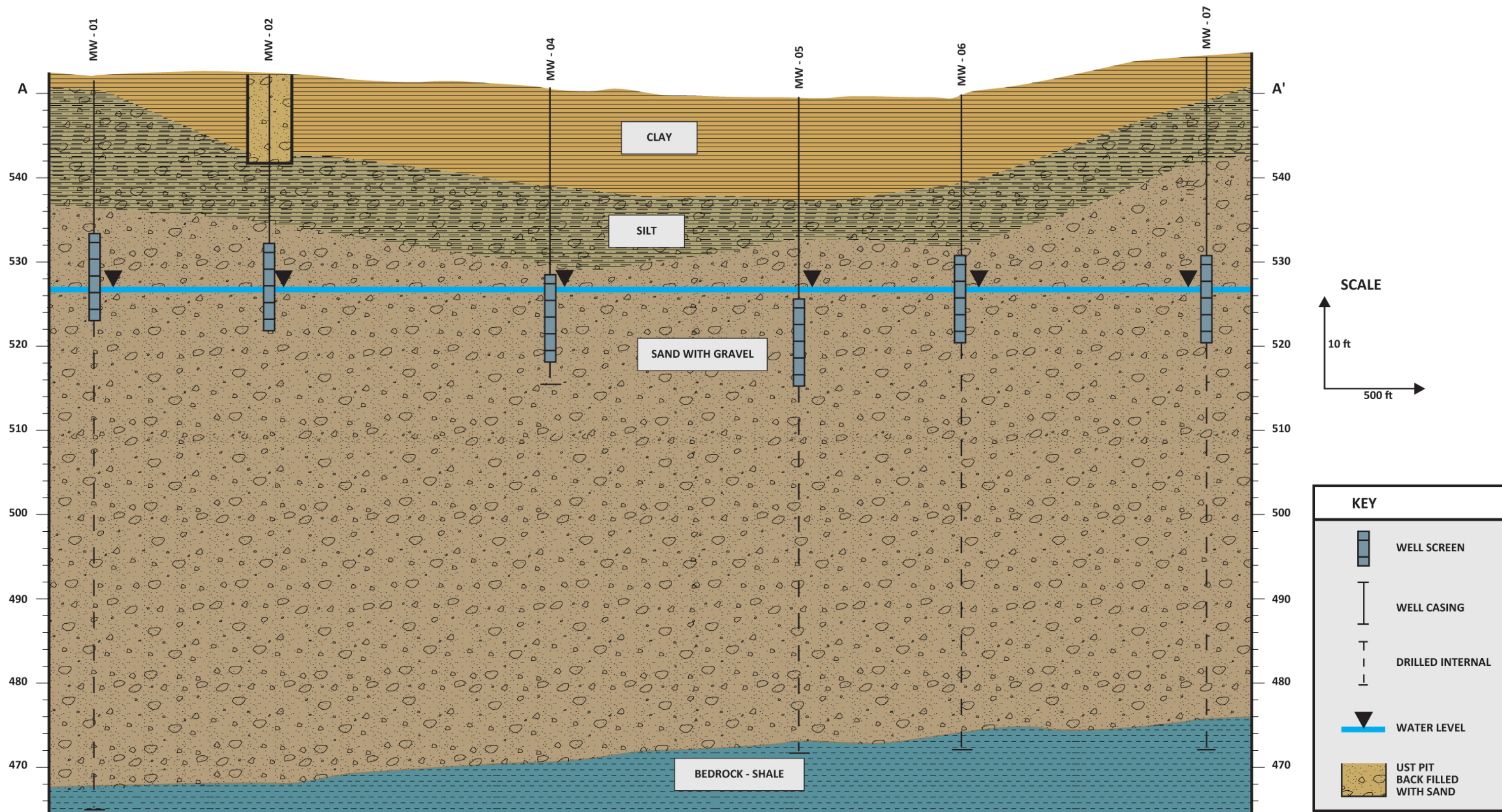
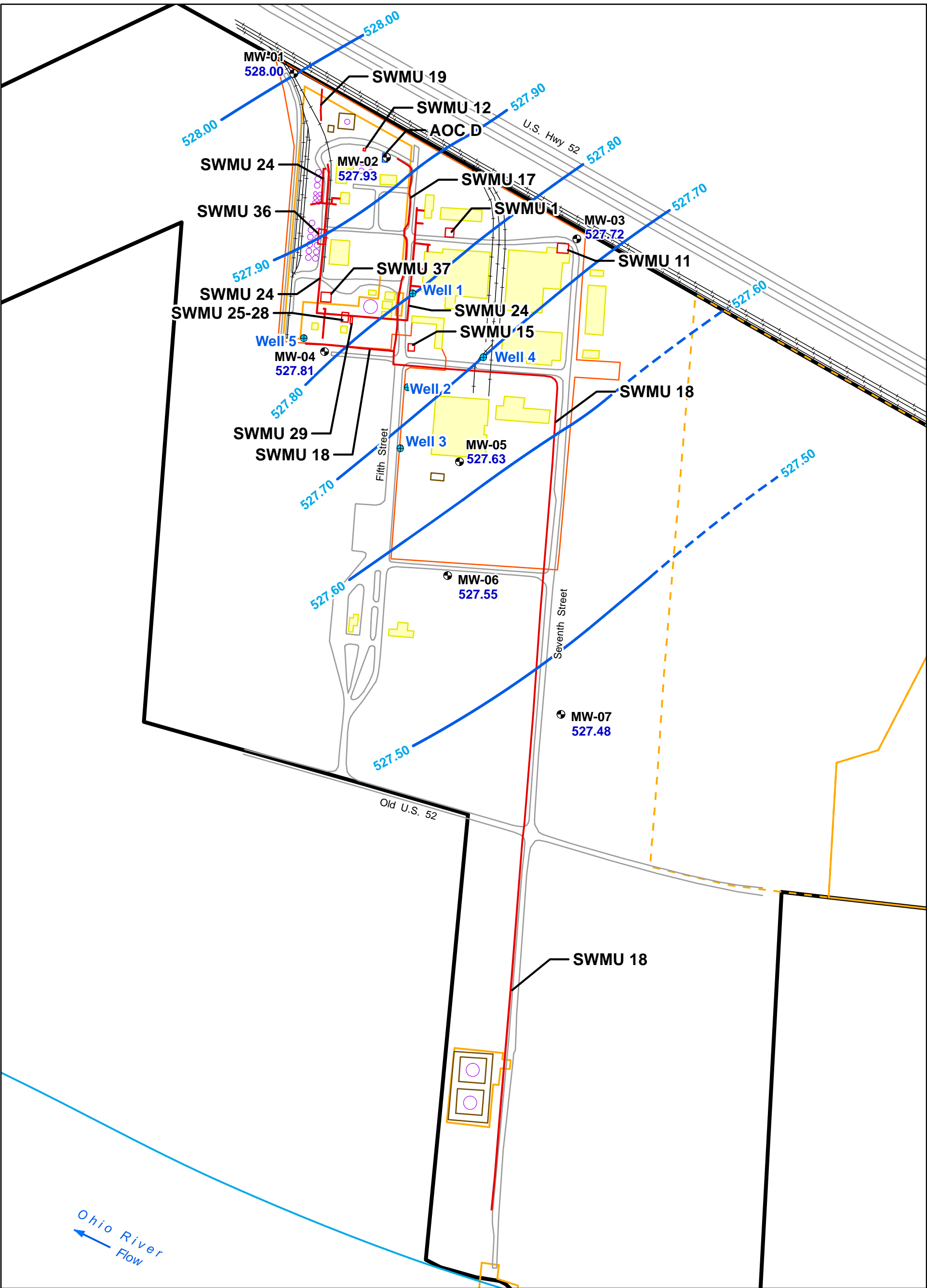


FIGURE 1-4  
**Cross Section A - A'**  
 Dow Hanging Rock Phase 2 RFI Work Plan  
 Ironton, OH



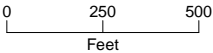


LEGEND

- |                           |  |
|---------------------------|--|
| Approximate Site Boundary | Miscellaneous Structure  |
| AOC                       | Tank   |
| SWMU                      | Building   |
| Railroad                  | Property Owned or Leased by Others (Dashed = Assumed Boundary) |
| Fence                     | Approximate Water Well Location                                |
| Edge of Road              |  |

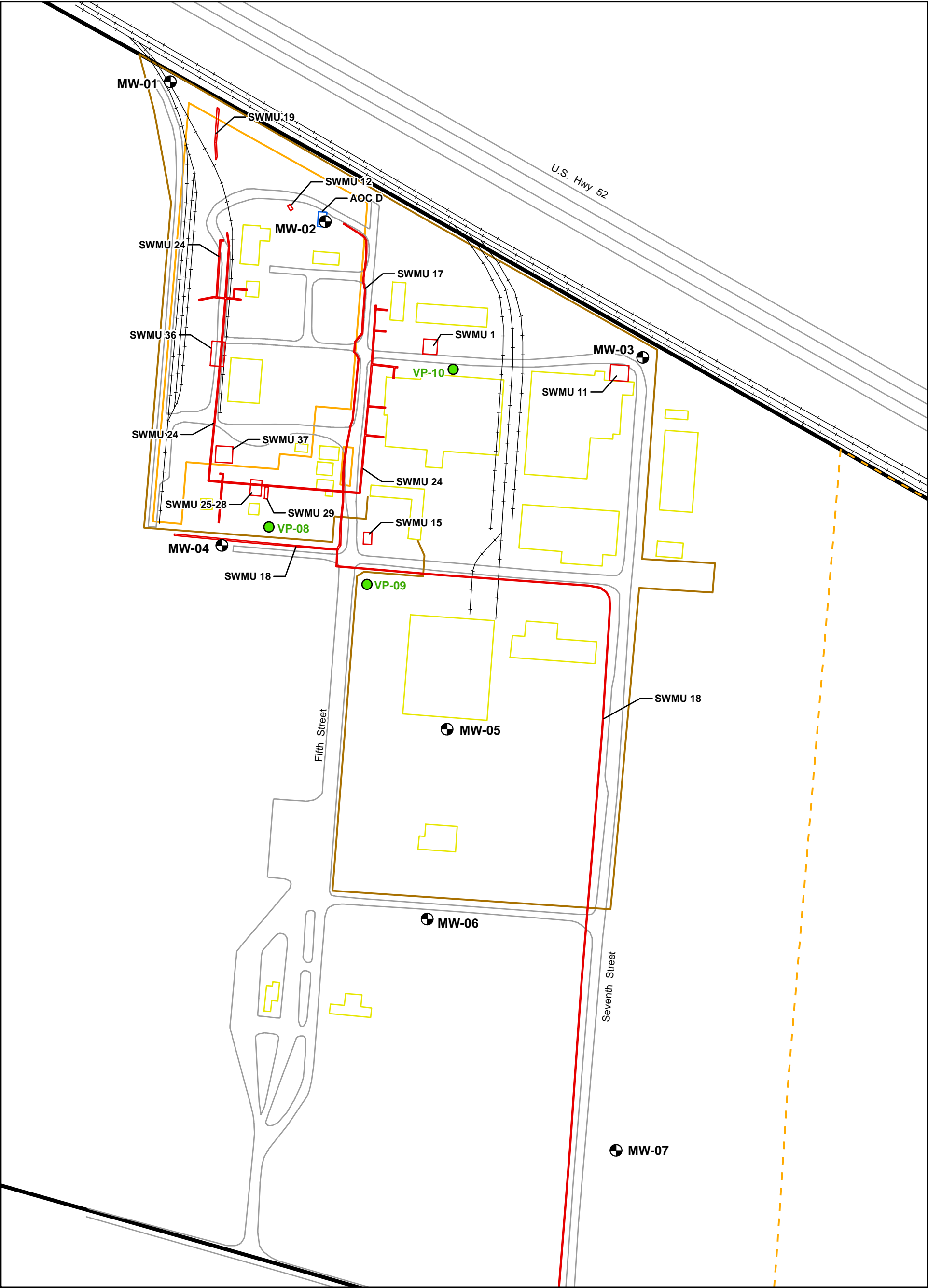
- |  |
|--|
| Monitoring Well                        |
| Groundwater Elevation Contour          |
| Groundwater Elevation Contour Inferred |

Note:  
1. Monitoring wells MW-01 through MW-07 were gauged on 1/17/2012. This data was used to generate the potentiometric surface.



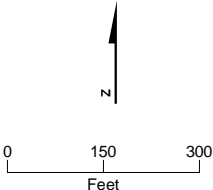
**FIGURE 1-5**  
**Potentiometric Surface Map**  
Dow Hanging Rock Phase 2 RFI Work Plan  
Ironton, Ohio

CH2MHILL



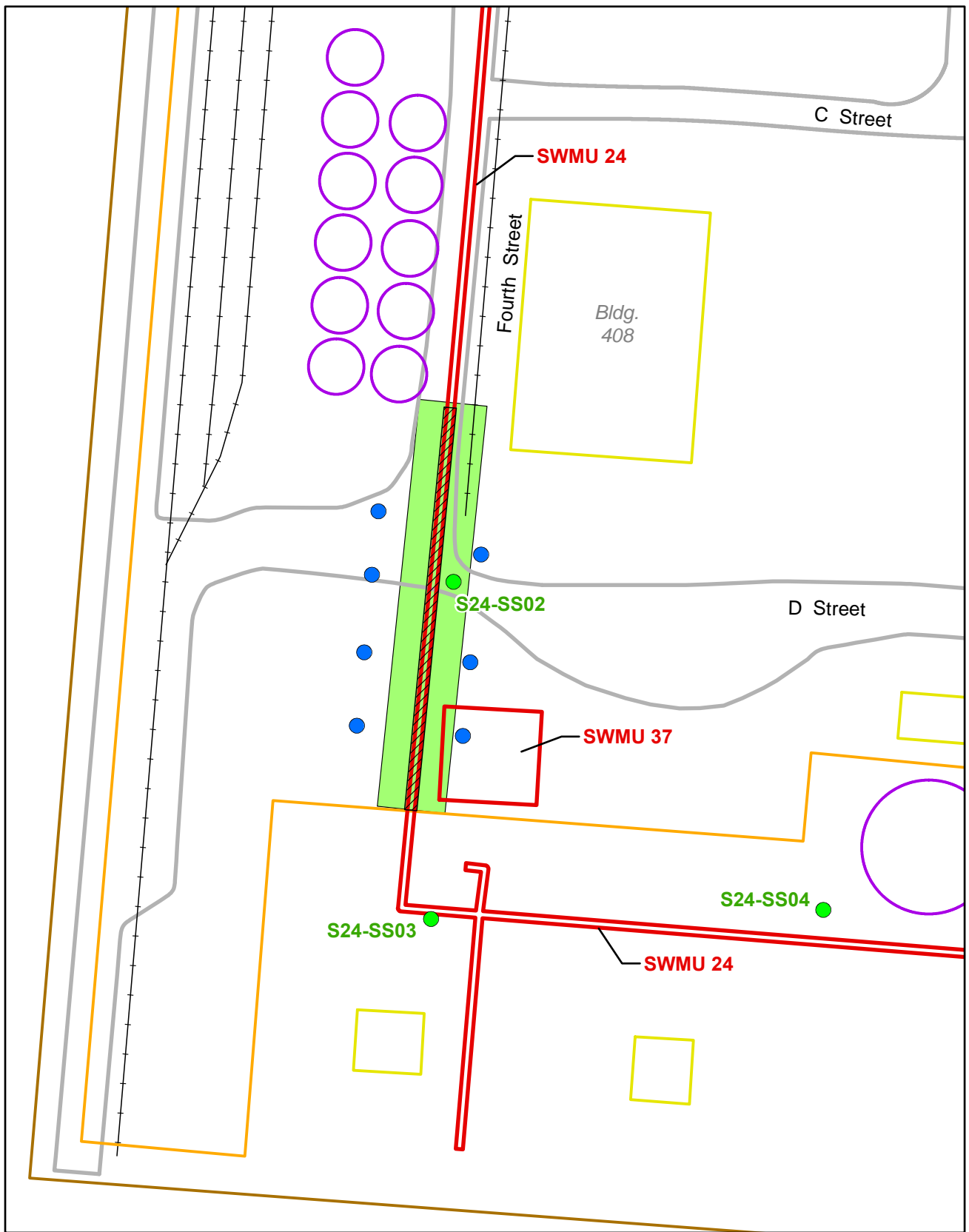
LEGEND

- |  |                           |
|--|---------------------------|
| Approximate Site Boundary                                      | Railroad                  |
| AOC  | Fence                     |
| SWMU   | Edge of Road              |
| Building   | Monitoring Well           |
| Property Owned or Leased by Others (Dashed = Assumed Boundary) | Vertical Profile Location |



**FIGURE 2-1**  
**Proposed Groundwater Sample Locations**

Dow Hanging Rock Phase 2 RFI Work Plan  
Ironton, Ohio



**LEGEND**

  SWMU

  Property Owned or Leased by Others

  Tank

  Building

  Approximate Location of Process Sewer Line Voluntary Closure Excavation Area

Proposed MIP Investigation

Railroad

Fence

Edge of Road

Monitoring Well

● Soil Sample Location

● Proposed MIP Location

0 40 80  
Feet



**FIGURE 2-2**  
**SWMU 24 – Proposed**  
**MIP Investigation**

Dow Hanging Rock  
Ironton, Ohio

**CH2MHILL**

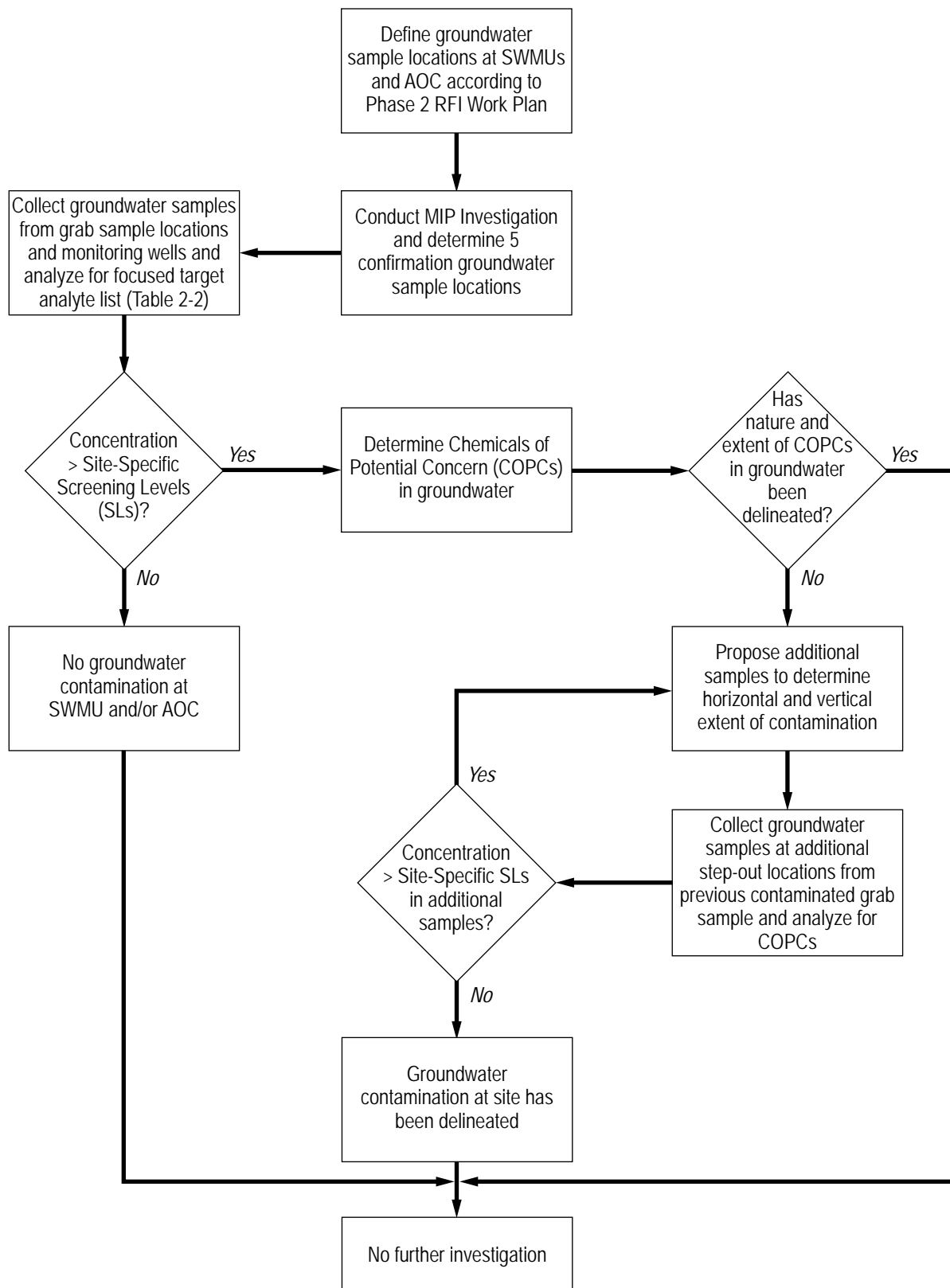


FIGURE 2-3  
**Decision Matrix-Groundwater**  
Dow Hanging Rock Phase 2 RFI Work Plan  
Ironton, Ohio

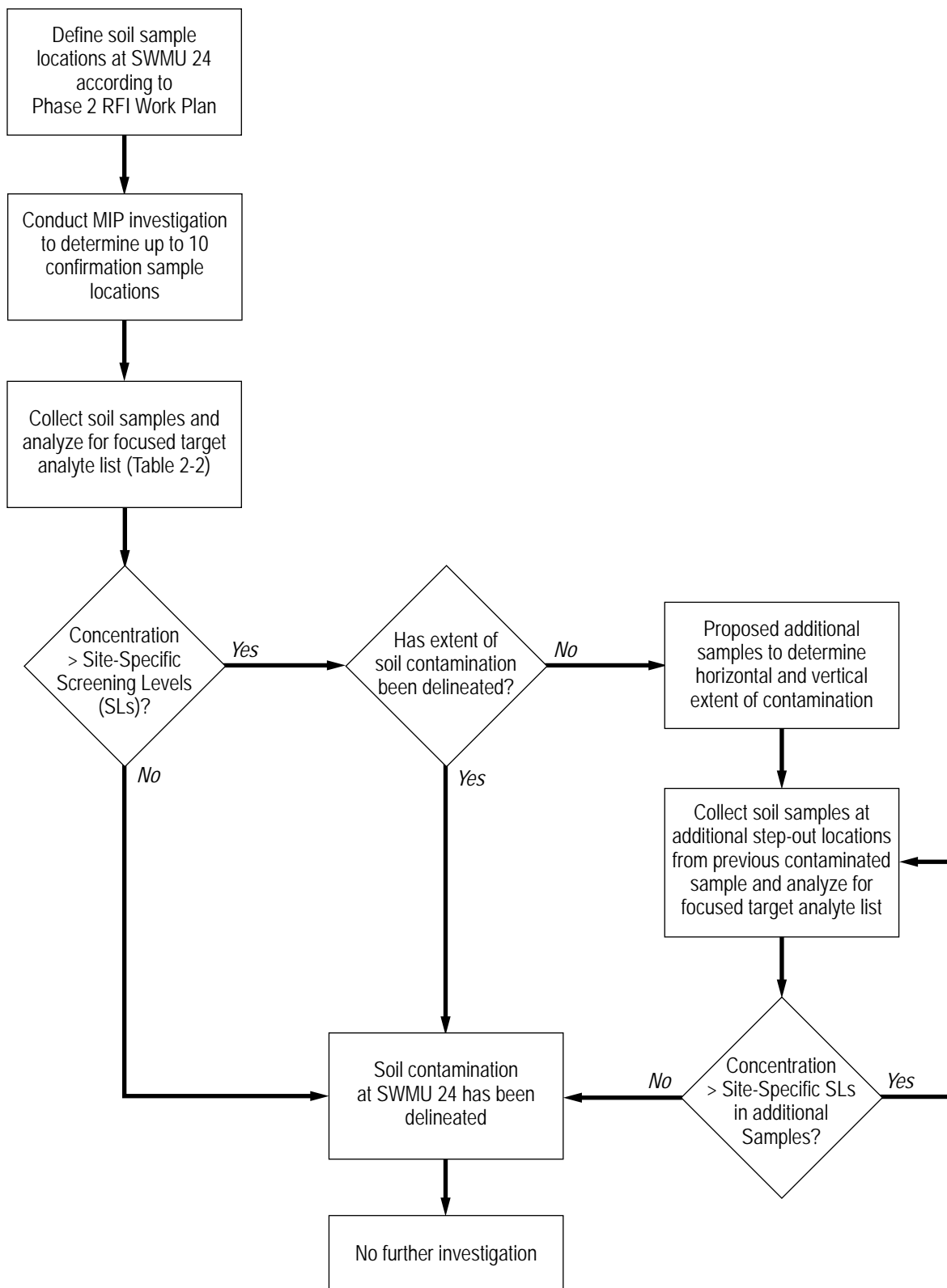


FIGURE 2-4  
**Decision Matrix-Soil**  
Dow Hanging Rock Phase 2 RFI Work Plan  
Ironton, Ohio

**Appendix A**  
**Standard Operating Procedures**

---



Groundwater Purging and Sampling Form											
Project Name:				Project Number:				Sheet      of			
Sample Source (Well No./Location):				Date:							
Weather Conditions:											
Well Condition:											
Sample Team:											
Sample Equipment:											
Well Stabilization Data											
Datum:				Well Volume:				Time Purging begins (T <sub>0</sub> ):			
Well Depth:		(ft)		1V = _____		(gal)		Water Level at time T <sub>0</sub> :			
Static Water Level:		(ft btoc)		3V = _____		(gal)		Time Purging ends (T <sub>1</sub> ):			
Water Column:		(ft)		5V = _____		(gal)		Water Level at time T <sub>1</sub> :			
Diameter:				Pumping System Volume:							
Time	Volume Removed Gal	pH + / - 0.1	ORP +/- 10 mV	SPCOND.(mS/cm) + / - 50umhos/cm	TEMP.(C) + / - 0.5	Redox (mV) + / - 10 mV	Water level (Ft) < 0.1 ft	D.O. (mg/L) + / - 10%	Turbidity (NTU)	Purge rate (LPM)	Appearance
Sample Information											

# Low-Flow Groundwater Sampling

---

## Purpose and Scope

This procedure presents general guidelines for collecting groundwater or groundwater grab samples from existing monitoring wells or temporary wells established within direct-push technology or hollow-stem auger soil borings using low-recovery sampling techniques. The SOP, Water Level Measurements, should be consulted in conjunction with this SOP. This SOP does not cover purging and sampling of monitoring wells by bailing or other high-flow methods. High-flow methods are not expected to be used.

The collection of groundwater samples from monitoring wells using the low-flow method will be accomplished in four general steps:

1. Determine the sustainable purge flow rate for the well.
2. Obtain stabilized water level in the well.
3. Obtain stabilized water quality indicator parameters.
4. Collect groundwater samples.

To avoid cross-contamination, wells will be purged and sampled in order so that the well having the lowest suspected contamination is sampled first, and the well having the highest suspected contamination is sampled last. (*Note:* It is important to “flush” the pumping system with groundwater to remove residues from the last operation, regardless of whether the pump is dedicated or portable.)

## Equipment and Materials

- Field log book
- Clean latex or nitrile gloves
- Clean DOT-approved 55-gallon steel drum with label
- Clean 5-gallon bucket (optional)
- Peristaltic pump with portable battery
- Water level meter
- Disposable polyethylene tubing
- Disposable silicon tubing
- Disposable filters to connect to pumps
- Equipment/instrument decontamination materials (See SOP, Decontamination of Personnel and Equipment.)

- Laboratory-supplied analytical sample containers
- Groundwater quality meter capable of collecting groundwater quality parameters either within the well riser or using a flow-through cell (Horiba U-22 Water Quality Multiprobe; capable of measuring temperature, specific conductance, dissolved oxygen, turbidity, pH, and oxygen-reduction potential or equivalent)

## Water Quality Indicator Parameters

The six field indicator parameters to be monitored are dissolved oxygen, turbidity, Eh (ORP), specific conductance, pH, and temperature. Of these, dissolved oxygen, ORP, specific conductance, pH, and temperature are moderately to extremely sensitive to contact with atmospheric oxygen, and will be measured in-line using a flow-through or downhole cell. Turbidity may be measured separately on a discrete sample. Indicator parameters will be monitored continuously during purging and values recorded every 3 to 5 minutes.

### Dissolved Oxygen, ORP, Specific Conductance, pH, and Temperature

Stabilization is mathematically defined as an asymptote (i.e., the slope of a plotted curve for each parameter is no longer changing). The operational criteria for dissolved oxygen, ORP, specific conductance, pH, and temperature are three successive readings at 5-minute intervals (for flow rate equal to or greater than 100 mL/min) within the following ranges:

- Dissolved oxygen:  $\pm 0.1$  mg/L for values  $< 1$  mg/L, *or*  $\pm 10\%$  for values  $> 1$  mg/L
- Eh (ORP):  $\pm 10$  mV
- Specific conductance:  $\pm 1\%$  of full-scale reading (instrument repeatability) *or* default  $\pm 20$   $\mu\text{mho/cm}$
- pH:  $\pm 0.1$  unit
- Temperature:  $\pm 0.5$  °C

### Turbidity

Turbidity is considered stabilized if values are less than 50 NTU for three successive readings at 5-minute intervals (assuming a 100 mL/minute flow rate). If the other parameters stabilize but turbidity remains  $> 50$  NTU, field personnel should continue purging at the determined sustainable flow rate to see whether the turbidity decreases with additional pumping. If turbidity does not decrease, the project manager should be notified.

## Procedures and Guidelines

A “low-recovery” well is a well in which stabilized water level cannot be obtained, regardless of pumping rate or equipment type. If a purge rate of 100 mL/min causes excessive drawdown or alternative equipment with flow rates less than 100 mL/minute cannot be used, the following procedure should be used:

1. Set up and calibrate instruments in accordance with manufacturer’s instructions.

2. Decontaminate sampling equipment and other instruments to be placed in the monitoring or temporary well riser before sampling in accordance with the SOP, Decontamination of Personnel and Equipment.
3. Before performing low-flow sampling, measure the depth to groundwater as described in the SOP, Water Level Measurements. **Do not measure the depth to the bottom of the well at this time** in order to reduce the possibility that accumulated sediment in the well will be disturbed. Obtain depth to bottom information from soil boring or monitoring well installation log. (If required, perform a sitewide groundwater monitoring event to obtain groundwater elevations for monitoring wells at the site.)
4. Place field equipment and supplies on clean plastic sheeting to minimize contamination.
5. Collect the following information:
  - Obtain well casing and borehole diameters.
  - Determine saturated casing volume and saturated borehole volume (casing volume + saturated filter pack volume).
  - Determine saturated casing volume above the pump intake.
  - Determine sampling system volume (volume capacity of pump, tubing, and flow-through cell).
  - Determine volume necessary to collect required samples, including quality assurance/quality control samples.
6. Determine whether the saturated casing volume above the pump intake is sufficient for at least two sampling system volumes plus required samples.
7. If the casing volume above the pump intake is sufficient for at least two sampling system volumes plus required samples, purge slowly at a constant flow rate, measure and record water level and field indicator parameters every 500 mL until two (or available) system volumes have been removed, collect samples, and document conditions and procedures. (*Note:* Water level will not be stable [that is, drawdown will occur] and indicator parameters may not be stable.)
8. If the casing volume above the pump intake is not sufficient for at least two sampling system volumes plus required samples, but is sufficient for at least one sampling system volumes plus required samples, purge slowly at a constant flow rate; measure and record water level and field indicator parameters every 500 mL until one (or available) system volumes have been removed; collect samples; document conditions and procedures. (*Note:* Water level will not be stable [that is, drawdown will occur] and indicator parameters may not be stable.)
9. If the casing volume above the pump intake is sufficient for required samples only, determine whether it is acceptable to collect samples without purging. If this is acceptable for project purposes, collect samples at a constant flow rate without purging, document conditions and procedures.
10. If the casing volume above the pump intake is not sufficient for required samples, determine whether samples can be prioritized and if it is acceptable to collect priority

samples without purging. If this is acceptable for project purposes, collect the priority samples at a constant flow rate without purging, document conditions and procedures.

11. If the casing volume above the pump intake is not sufficient for required samples, samples cannot be prioritized, or it is unacceptable for project purposes to collect samples without purging, do not sample and document conditions.
12. If the well cannot be sampled using the low-recharge procedure determine whether the well can be removed from the monitoring network.

Based on the volume of water available, continue to sample the location as described below.

13. Connect the silicone tubing to the peristaltic pump.
14. Strap the end of the polyethylene tubing to either a downhole or flow-through water quality indicator instruments. Ensure that the bottom of the tubing is located at the same depth as the sensors. Cut the excess of cable straps.
15. Slowly lower the polyethylene tubing to the top of the water column.
16. Cut the polyethylene tubing and connect to the silicone tubing in the peristaltic pump. Allow for enough excess polyethylene tubing in the event that water does not recharge as fast as the pumping rate, therefore needing to lower the tubing further into the well.
17. Turn on the groundwater parameter field instrument and let the readings stabilize. Once temperature has stabilized for 30 seconds, record initial groundwater parameters and depth to groundwater on a Groundwater Monitoring Well Purging and Sampling form.
18. Ensure that the pump flow direction is correct on the peristaltic pump. Turn pump on and adjust the flow rate as to not exceed 0.1 L/min (0.026 gal./min). If the saturated casing volume above pump intake is sufficient for purging, purged groundwater can be initially containerized in a plastic 5-gallon bucket and subsequently transferred to a clean 55-gallon drum.
19. If the saturated casing volume above the pump intake is sufficient for at least 1 or 2 sampling system volumes plus required samples, purge slowly at a constant flow rate not to exceed 0.1 L/min; measure and record water level and water quality indicator parameters every 500 mL until one or two (or available) system volumes have been removed; collect samples; document conditions and procedures. (*Note: Water level will not be stable [that is, drawdown will occur], and indicator parameters may not be stable.*)
20. Pump the groundwater directly into the sample bottles immediately after purging the well, if purging prior to sampling occurs. Sample collection shall occur once pumping begins if the groundwater is not purged prior to sampling. As noted, the saturated casing volume above the pump intake will dictate whether the well is purged before sampling. Attach filter to the pump last to collect groundwater into sample bottles for dissolved metals analysis. Flow must be at a rate as to not create bubbles within the sample bottle and the sampler will ensure the water column in the tubing is solid. (See SOP, Water Sample Collection for Trichloroethene, cis-1,2-Dichloroethene, and Vinyl Chloride.)

21. If sufficient groundwater is not available to fill each analytical sample containers, leave the protected screen in place and allow the groundwater to recharge. Check the screen from time to time, and attempt to sample more groundwater until analytical sample containers have been filled.
22. Groundwater shall be directly pumped into the sample bottles immediately after pumping of the borehole begins. For samples, the flow of the pump shall be at a rate as to not create bubbles within the sample bottle and the sampler will ensure the water column in the tubing is solid. (See SOP, Water Sample Collection for Trichloroethene, cis-1,2-Dichloroethene, and Vinyl Chloride.)
23. Following collection of groundwater grab samples, remove the PVC riser/screen from the soil boring. The PVC riser and screen, if used, and polyethylene tubing will be discarded.
24. Backfill the boring with grout or hydrated bentonite chips, and repair the surface with like material (asphalt patch, concrete) as required.
25. Store instruments in accordance with the manufacturer's instructions.
26. Purged groundwater will be considered containerized in U.S. DOT-approved 55-gallon steel drums. CH2M HILL will label, date, and transport the drums to a designated site for temporary storage.

## Key Checks

- Ensure that Horiba, YSI, or equivalent sonde sensors are calibrated and cared for in accordance with manufacturer's instructions.
- Ensure that Horiba, YSI, or equivalent sensors are located below the groundwater surface to provide groundwater quality parameter readings.
- Check that the flow direction switch on the peristaltic pump is in the correct direction. Flow in the wrong direction may create bubbles in the well riser, thus affecting dissolved oxygen readings.
- Charge battery to peristaltic pump and Horiba, YSI, or equivalent data collector when not in use. Low battery on the Horiba, YSI, or equivalent data collector may not allow unit to connect properly with sonde.

## Attachments

Groundwater Monitoring Well Purging and Sampling form

# Direct-Push Technology Soil Sampling

---

## Purpose

To provide general guidelines for the collection and handling of direct-push soil samples during field operations.

## Scope and Applicability

The method described for direct soil sampling is applicable for soil sampling at and below ground surface using direct-push techniques. Equipment and responsibilities of direct-push subcontractors are described in the contracting documentation.

The direct-push sampling system uses a sample barrel that is pushed, pounded, or vibrated into the ground by a drilling rig or similar, and soil samples are collected in liners inside the sample barrel. The drive casing sample barrel typically has an outside diameter of 3.5 inches. The sample barrel is made up of a 2-to 4-foot long section of thin walled steel tubing and contains a clear butyl or acetate liner insert capable of collecting 2.6-inch-diameter soil cores. Sample intervals are typically 4 feet, but range from 2 to 5 feet in length.

## Technical Practice Details

### Equipment / Materials

#### Provided by the Direct-push Operator

- Direct-push rig, rods, and barrels
- Acetate or butyl liner
- Double hook-bladed knife for opening liners (the double hook style blade is critical for safety)

#### Health and Safety

- PID and/or FID
- Sampling gloves as specified in the H&S Plan

#### Decontamination

- Decontamination solutions (as specified in the *Field Sampling Equipment Decontamination SOP*)
- Brushes and containment basins

#### Sampling (as appropriate)

- Plastic Sheeting
- Sample Containers

- Sampling bowls and spoons
- Encore VOC sampling equipment
- Camera and Film
- Sample Table and Plastic Cover
- Plastic Trash Bags
- Indelible Marking Pens
- Black Permanent Ink Pen (Sharpie or similar)
- Field Sampling Logbook
- Duct Tape
- Sampling Form

### Sample Packing

- Appropriate Packing Cartons and Filler
- Labels
- Chain-of-Custody Documents
- Coolers for Sample Shipping and Cooling
- Knife
- Double-Bagged Ice
- Strapping Tape
- Sealable Baggies

## Procedures / Guidelines

### Acquire and Log the Soil Sample

1. *Prepare the Sampling Station:* Set up the sample area (can be a table, tailgate of field vehicle, or an area provided by the drillers) adjacent to the well and cover the top with clear sheet plastic to minimize contamination of the sample area. Tape the plastic and record the sample location, site, anticipated sample time, and field sample number onto the plastic using an indelible pen. Fill out the sample labels and place on the appropriate sample containers. Labels must be waterproof to prevent water damage. The following information must be included on the sample label:

- Site name
- Field identification or sample station number
- Date and time of sample collection
- Designation of the sample as grab or composite
- Type of sample (matrix) and a brief description of the sampling location
- Printed full name of the sampler
- Sample preservative used
- Type of analyses to be performed

If a sample is split with another party, sample labels with identical information should be attached to each of the sample containers.

2. *Take a Station Photograph:* Position the labeled sample containers and required trip blanks on the sample table so that the sampling information on the plastic is legible and then



take a photograph of the sampling setup. Only take photographs if this is necessary and allowed by client site representatives.

3. *Position Rig*: Have the drilling subcontractor position the direct-push equipment over the approved sample location. Record sample location, time, and date of sampling in field logbook.
4. *Collect Sample*: The driller will collect the soil sample using the direct-push system. After the equipment operator removes the sample barrel from the drive casing, he/she will remove the liner from the sample barrel, split it lengthwise with the double-hooked bladed tool, and will turn the liner over to the team geologist.
5. *Open and Log Sample*: Log the core and record the data on a standard log sheet or logbook. Conduct PID readings and record the data on the boring log form. Photograph the soil sample, if appropriate.
6. *Take Headspace*: Perform the headspace analysis for volatile organic vapors on a representative sample from the sample barrel. Record the data on the soil logging form or in the field logbook.
7. *Take the Soil Sample*: Take the VOC portion of the soil sample first directly from the sample core, using the Encore or equivalent procedure. After the Encore (or equivalent technology) VOC samples have been taken and placed in the cooler on ice, take the remaining analytical samples.

Samples for the remaining analytical suite can be collected after homogenizing the sample core in a decontaminated, stainless steel bowl or a plastic, sealable bag. Use a decontaminated spoon and place a representative portion of the entire sample length in each sample container. Tightly pack the sample and screw on the container lid. Immediately place the samples in a cooler with ice. Do not leave the sample exposed to the sun or extreme temperatures.

8. *Decontaminate Tools*: Decontaminate the pan or bowl, and media transfer tools before using to collect another sample. Refer to the *Field Sampling Equipment Decontamination SOP*.
9. *Driller Decontamination*: The driller is responsible for decontaminating drilling tools, such as core barrels. Refer to the *Field Sampling Equipment Decontamination SOP*, as appropriate. Document the procedure used by the drillers for decontamination in the logbook.
10. *Record Keeping*:
  - Record sample description, depth, and time and date of sampling in field logbook.
  - Fill out the chain-of-custody form.
11. *Manage IDW*: Discard the unused sample in accordance with IDW requirements

**Warning:** Do not let the liners sit in the sun or in a warm environment. If a liner filled with soil cannot be sampled immediately, it must be cooled with ice until the sampling can proceed.

### Quality Control Samples

Quality control samples that are collected with soil samples include duplicates, matrix spike/matrix spike duplicate (MS/MSD), trip blanks, and equipment blanks. Of these, trip blanks and equipment blanks are aqueous and do not require extra soil volume. If a duplicate or MS/MSD sample is required at a sampling location, then a second direct push liner sample may be required (if there is insufficient sample in the original sample liner). The additional sample is to be obtained in a borehole immediately adjacent to the original location and from the same depth interval. The MS/MSD sample will be submitted to the laboratory with the original sample, and the duplicate will be submitted to the laboratory as a separate sample. The number of sampling locations that require an MS/MSD or duplicate sample should be predetermined.

### Key Checks / Items

- Make sure the liner samples are kept at a temperature of 4° C if they cannot be immediately sampled
- Determine if a QC sample will be required at a sampling location. If a QC MS/MSD or duplicate soil sample will be needed, then additional sample volume will be required. Additional sample volume may be acquired by pushing another soil sample.
- Ensure that all tools that may come into contact with the sample, a team member, other equipment, or non-contaminated environment are properly decontaminated.
- Collect rinse water investigation-derived waste from decontamination activities

## STANDARD OPERATING PROCEDURE

# Direct-Push Groundwater Grab Sample Collection

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## Purpose

To provide a general guideline for the collection of groundwater samples using direct-push (e.g., Geoprobe®) sampling methods.

## Scope

Standard direct-push (e.g., Geoprobe®) groundwater sampling methods.

## Equipment and Materials

- Truck-mounted hydraulic percussion hammer.
- Direct-push (e.g., Geoprobe®) sampling rods and slotted lead rod
- Polyethylene sampling tubing and stainless steel foot valve
- Pre-cleaned sample containers
- Clean latex or surgical gloves.

## Procedures and Guidelines

1. Decontaminate slotted lead rod and other downhole equipment in accordance with SOP *Decontamination of Personnel and Equipment*.
2. Drive slotted steel lead rod to the desired sampling depth using the truck-mounted hydraulic percussion hammer.
3. Insert the stainless steel foot valve into the end of the polyethylene sampling tubing and insert tubing through the rods.
4. Purge groundwater from the sampling interval until either the sediment has visually cleared up to the extent practical based on the FTL's professional judgment or purging has lasted 15 minutes.
5. Fill all sample containers, beginning with the containers for VOC analysis.
6. Remove polyethylene sampling tubing from the rods. Remove the foot valve and discard polyethylene tubing.
7. Backfill borehole at each sampling location with grout or bentonite and repair the surface with like material (bentonite, asphalt patch, concrete, etc.), as required.

## Key Checks and Items

- Verify that the hydraulic percussion hammer is clean and in proper working order.
- Ensure that the direct-push operator thoroughly completes the decontamination process between sampling locations.
- Ensure that the slotted lead rod has been inserted to the desired sampling depth.
- Verify that the borehole made during sampling activities has been properly backfilled.

## STANDARD OPERATING PROCEDURE

# Sediment Sampling

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## Purpose

This standard operating procedure (SOP) practice describes collecting and handling sediment samples during field operations using sediment scoop samplers.

## Scope and Applicability

This sediment sampling procedure is applicable to collecting representative surficial sediment samples using a sediment scoop sampler and hand trowel. Refer to the specific requirements of the project and sample handling procedures described in the work plan when using this SOP during field activities.

## Example Equipment / Materials

- Scoop sediment sampler or hand trowel
- Stainless steel spoon or spatula for sediment sample transfer
- Stainless steel bowls or pans
- Measuring tape
- Logbook and waterproof and permanent marker
- Personal protection equipment (rubber or latex gloves, boots, hip waders, etc.)
- Samples bottles
- Cooler with ice
- Paper towel or Kimwipes

## Scoop Sediment Sampler

A scoop sampler consists of a glass jar, a high-density polyethylene wide-mouth jar, or a stainless steel scoop, typically clamped to a pole. The pole may be made of wood or plastic and be either fixed length or telescoping. If the water body can be sampled from the shore or if it can be waded into, the easiest and “cleanest” way to collect a sample is to use the scoop sampler because it reduces the potential for cross-contamination. This method is performed by reaching over or wading into the water body and, while facing upstream into the current, gently lowering the scoop into the water until it is resting on the substrate. Ensure the area upstream, which is to be sampled, is undisturbed.

In a single, smooth action, sweep the scoop sampler along the bottom, moving it upstream and then out of the water column. Do not return the scoop to collect additional sample volume from the same location until the collected sample is removed from the scoop. When performing replicate sampling for additional volume, avoid sampling areas previously sampled.

The scoop sampler method is effective in shallow water environments (less than 1 foot deep) and when collecting for small volumes of sample. The scoop sampler method is also effective in areas that have small pockets of sample material, such as pockets of sand on a cobble beach. It is difficult not to disturb fine-grained materials at the sediment/water interface. It is usually effective in fine-grained substrates and only samples the top 3 to 5 centimeters.

## Hand Trowel

A hand trowel is a tool with a pointed, scoop-shaped metal blade and a handle. It is used for breaking up earth and digging small holes in soft sediments.

If the surface water body can be waded, the easiest way to collect a sediment sample is by using a stainless steel scoop or hand trowel. The sampling method is accomplished by wading into the surface water body and while facing upstream (into the current), scooping the sample along the bottom of the surface water body in the upstream direction. Excess water may be removed from the scoop or spoon. However, this may result in the loss of some fine-particle material associated with the bottom of the surface water body.

This method can be used to collect consolidated sediments but is limited somewhat by the depth of the aqueous layer. Accurate, representative samples can be collected with this procedure, depending on the care and precision demonstrated by the sample team member. In surface water bodies that are too deep to wade, but are less than 8 feet deep, a scoop sediment sampler or spoon attached to a piece of conduit can be used either from the banks if the surface water body is narrow or from a boat. The sediment is placed into a glass pan and homogenized. A stainless steel or plastic scoop or lab spoon will suffice in most applications. Care should be exercised to avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden trowels. Follow these procedures to collect sediment samples with a scoop or trowel:

- Using a pre-cleaned stainless steel scoop or trowel, remove the desired thickness of sediment from the sampling area.
- Transfer the sample into an appropriate sample or homogenization container

## Typical Procedures / Guidelines

- Make a sketch of the sample area, showing nearby features and permanent structures that can be used to locate the sample points on a map. Whenever possible, include measured distances from such identifying features. Include depth and width of waterway, rate of flow, type and consistency of sediment, and point and depth of sample removal (e.g., along shore, mid-channel).
- Start downstream and work upstream to prevent contamination of unsampled areas.
- Collect the sediment sample using the appropriate sampling method as described in the work plan/field sampling plan.

- Ensure all field observations are recorded completely and correctly. After the sample is judged acceptable, the following observations should be recorded:
  - Station location indicated on the global positioning system instrument
  - Station depth
  - Gross characteristics of the sediment
    - Texture
    - Color
    - Biological structures (e.g., shells, tubes, macrophytes)
    - Presence of debris (e.g., wood chips, wood fibers, human artifacts)
    - Presence of oily sheen
    - Odor (e.g., hydrogen sulfide, oil, creosote)
- Before subsamples of the surficial sediments are taken, the overlying water must be removed. The preferred method of removing this water is by slowly siphoning it off near one side of the sampler. This can be done using a peristaltic pump, or in a similar siphoning-type device. Methods such as decanting the water or slightly cracking the grab to let the water run out are not recommended because they may result in unacceptable disturbance or loss of fine-grained surficial sediment and organic matter.
- Once the overlying water has been removed, the surficial sediment can be subsampled. When subsampling surficial sediments, unrepresentative material should be removed in the field and noted on the field log sheet.
- Transfer sample into sample jars as specified in the work plan/field sampling plan and quality assurance project plan using a stainless steel spoon or utensil. Never touch the sediment sample because gloves may introduce organic contamination into the sample.
- Fill out necessary chain-of-custody forms.
- Decontaminate all sampling implements and protective clothing according to prescribed procedures.

## Key Checks / Items

- Start downstream, work upstream.
- Log exact locations using permanent features.
- Work safely. Beware of hidden hazards under the water.



**A hand trowel**

# Logging of Soil Borings

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## Purpose and Scope

This standard operating procedure (SOP) provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

## Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCl, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification (attached)

## Procedures and Guidelines

This section covers several aspects of the soil characterization: instructions for completing the CH2M HILL soil boring log Form D1586 (attached), field classification of soil, and standard penetration test procedures.

### Instructions for Completing Soil Boring Logs

- Soil boring logs will be completed in the field logbooks or on separate soil boring log sheets. Information collected will be consistent with that required for Form D1586 (attached), a standard CH2M HILL form, or an equivalent form that supplies the same information.
- The information collected in the field to perform the soil characterization is described below.
- Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets.



## Heading Information

- **Boring/Well Number.** Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.
- **Location.** If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as “approximate” or “estimated” as appropriate.
- **Elevation.** Elevation will be determined at the conclusion of field activities.
- **Drilling Contractor.** Enter the name of the drilling company and the city and state where the company is based.
- **Drilling Method and Equipment.** Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.
- **Water Level and Date.** Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.
- **Date of Start and Finish.** Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.
- **Logger.** Enter the first initial and full last name.

## Technical Data

- **Depth Below Surface.** Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.
- **Sample Interval.** Note the depth at the top and bottom of the sample interval.
- **Sample Type and Number.** Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.
- **Sample Recovery.** Enter the length to the nearest 0.1 foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record recovery in feet.
- **Standard Penetration Test Results.** In this column, enter the number of blows required for each 6 inches of sampler penetration and the “N” value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as “WOH.”

- Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons. Samples may be collected using direct push sampling equipment. However, blow counts will not be available. A pocket penetrometer may be used instead to determine relative soil density.
- Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An “N” value need not be calculated.

### Soil Description

The soil classification should follow the format described in the “Field Classification of Soil” subsection below.

### Comments

Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions).

In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

### Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

- Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example “POORLY-GRADED SAND.”
- Group symbol, in parentheses, for example, “(SP).”
- Color, using Munsell color designation
- Moisture content
- Relative density or consistency
- Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

## Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as “Interlayered Sand and Silt,” should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

## Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

## Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

## Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

## Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D1586 [attached]). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in tables 3 and 4.

## Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength,

dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

## Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch O.D., and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is “A” rod (1-5/8-inch O.D.). A stiffer rod, such as an “N” rod (2-5/8-inch O.D.), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

## Attachments

Soil Boring Log, CH2M HILL Form D1586, and a completed example

ASTM D 2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)*

ASTM 1586 *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*

Tables 1 through 4

## Key Checks and Preventive Maintenance

- Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later.
- Check that sample numbers and intervals are properly specified.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP *Decontamination of Drilling Rigs and Equipment*.

# Soil Sampling

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## Purpose

To provide general guidelines for the collection and handling of direct-push samples during field operations.

## Scope and Applicability

The method described for direct soil sampling is applicable for soil sampling at and below ground surface using mechanized drilling equipment (i.e., direct push technology [DPT] or hollow stem auger). Equipment and responsibilities of the drilling subcontractors are described in the contracting documentation.

Note that particular handling and filling procedures are required for soil samples collected for volatile organic compound (VOC) analysis. Please refer to *VOC Soil Sampling* standard operating procedure (SOP) for specific procedures for collecting VOC samples.

## Equipment / Materials

### Provided by the Drilling Operator

- Drill rig and appropriate equipment

### Health and Safety

- Photoionization detector (PID) and/or flame ionization detector (FID)
- Sampling gloves as specified in the health and safety plan

### Decontamination

- Decontamination solutions (as specified in the *Field Sampling Equipment Decontamination* SOP)
- Brushes and containment basins

### Sampling (as appropriate)

- Plastic sheeting
- Sample containers
- Sampling bowls and spoons
- Encore VOC sampling equipment (refer to *VOC Soil Sampling* SOP)
- Camera and film
- Sample table and plastic cover
- Plastic trash bags
- Indelible marking pens
- Black permanent ink pen (Sharpie or similar)

- Field sampling logbook
- Duct tape
- Sampling form

### Sample Packing

- Appropriate packing cartons and filler
- Labels
- Chain-of-custody documents
- Coolers for sample shipping and cooling
- Knife
- Double-bagged ice
- Strapping tape
- Sealable baggies

## Procedures / Guidelines

### Acquire and Log the Soil Sample

1. *Prepare the Sampling Station:* Set up the sample table adjacent to the well and cover the tabletop with clear sheet plastic to minimize contamination of the table. Tape the plastic onto the table and record the sample location, site, anticipated sample time, and field sample number onto the plastic using an indelible pen. Fill out the sample labels and place on the appropriate sample containers. Labels must be waterproof to prevent water damage. The following information must be included on the sample label:
  - Site name
  - Field identification or sample station number
  - Date and time of sample collection
  - Designation of the sample as grab or composite
  - Type of sample (matrix) and a brief description of the sampling location
  - Printed full name of the sampler
  - Sample preservative used
  - Type of analyses to be performed

If a sample is split with another party, sample labels with identical information should be attached to each of the sample containers.

2. *Take a Station Photograph:* Position the labeled sample containers and required trip blanks on the sample table so the sampling information on the plastic is legible and then take a photograph of the sampling setup. Only take photographs if this is necessary and allowed by client site representatives.
3. *Position Rig:* Have the drilling subcontractor position the rig over the approved sample location. Place plastic sheeting under rig to prevent any fluids released from the rig from reaching the ground. Record sample location, time, and date of sampling in field logbook.

4. *Collect Sample:* After the equipment operator removes the sample barrel from the drive casing, he/she will remove the liner/casing from the sample barrel, split it lengthwise, and will turn it over to the team geologist.
5. *Open and Log Sample:* Log the core and record the data on a standard log sheet or logbook. Conduct PID readings and record the data on the boring log form. Photograph the soil sample, if appropriate.
6. *Take Headspace:* Perform the headspace analysis for volatile organic vapors on a representative sample from the sample barrel that has been placed in a resealable plastic bag in accordance with the *Air Monitoring with the OVM Instrument* or *Air Monitoring with the MultiRae Instrument* SOPs. Record the data on the soil logging form or in the field logbook.

After filling the resealable plastic bag, wait 5 minutes. If the ambient temperature is less than 50 degrees Fahrenheit (°F), move the sample into a warm place (greater than 50°F) and let the sample equilibrate for 5 minutes. After 5 minutes, take the reading by breaking the resealable plastic bag seal just enough to insert the probe of the PID/FID, inserting the probe, and recording the result.

7. *Take the Soil Sample:* Take the VOC portion of the soil sample first directly from the sample core, using the EnCore procedure, if necessary (refer to the *VOC Soil Sampling* SOP). After the EnCore VOC samples have been taken and placed in the cooler on ice, take the remaining analytical sample.

Samples for the remaining analytical suite can be collected after homogenizing the sample core in a decontaminated, stainless steel bowl. Use a decontaminated spoon and place a representative portion of the entire sample length in each sample container. Tightly pack the sample and screw on the container lid. Immediately place the samples in a cooler with ice. Do not leave the sample exposed to the sun or extreme temperatures.

8. *Decontaminate Tools:* Decontaminate the pan or bowl, and media transfer tools before using to collect another sample. Refer to the *Field Sampling Equipment Decontamination* SOP.
9. *Driller Decontamination:* The driller is responsible for decontaminating drilling tools, such as core barrels. Refer to the *Field Sampling Equipment Decontamination* SOP, as appropriate. Document the procedure used by the drillers for decontamination in the logbook.
10. *Record Keeping:*
  - Record sample description, depth, and time and date of sampling in field logbook.
  - Fill out the chain-of-custody form.
11. *Manage Investigation-Derived Waste (IDW):* Discard the unused sample in accordance with IDW requirements

**Warning:** Do not let the liners sit in the sun or in a warm environment. If a liner filled with soil cannot be sampled immediately, it must be cooled with ice until the sampling can proceed.



## Quality Control Samples

Quality control (QC) samples that are collected with soil samples include duplicates, matrix spike (MS)/matrix spike duplicates (MSDs), trip blanks, and equipment blanks. Of these, trip blanks and equipment blanks are aqueous and do not require extra soil volume. The MS/MSD sample will be submitted to the laboratory with the original sample, and the duplicate will be submitted to the laboratory as a separate sample. The number of sampling locations that require an MS/MSD or duplicate sample should be predetermined.

## Key Checks / Items

- Make sure the soil samples are kept at a temperature of approximately 4 degrees Celsius if they cannot be immediately sampled.
- Determine if a QC sample will be required at a sampling location. If a QC MS/MSD or duplicate soil sample will be needed, then additional sample volume will be required. Additional sample volume may be acquired by pushing another soil sample.
- Ensure plastic sheeting is placed under the rig to prevent any released fluids from the rig from reaching the ground.
- Ensure that all tools that may come into contact with the sample, a team member, other equipment, or non-contaminated environment are properly decontaminated.
- Collect rinse water investigation-derived waste from decontamination activities.

# VOC Soil Sampling

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## Purpose

This technical practice contains guidelines for collecting and handling soil volatile organic compound (VOC) samples using EnCore sampling techniques.

## Scope and Applicability

The method described for EnCore sampling is applicable for soil sampling of VOCs following SW 846 Method 5035 (Closed-System Purge and Trap and Extraction for Volatile Organics in Soil and Waste Samples).

## Technical Practice Details

### General

The EnCore sampler is a disposable volumetric sampling device developed to assist in taking VOC soils and sediment samples with minimal handling. The sampler has three components: the coring body, the plunger, and the cap. A reusable T-handle is used to assist in pushing the sampler into the material. The airtight sealing cap prevents the loss of volatiles. No chemicals (such as methanol) are to be used in the sampling process.

### Equipment / Materials

- EnCore samplers
- EnCore T-handle
- Latex or surgical gloves
- Stainless steel pan or bowl
- Field logbook
- Sealing plastic bags
- Decontamination solutions and equipment
- Air monitoring devices (such as photoionization detectors [PIDs])

### Procedures / Guidelines

The following procedures and guidelines refer to the macro sample as a “soil sample.” “VOC sample” or “VOC soil” refers to the sample extracted from the macro sample by the EnCore sampler.

## Acquire the Soil Sample

The taking of soil samples will vary slightly depending on the method of collection. Follow the directions specified in this standard operating procedure (SOP) for the specific sampling methodology.

1. Have the drilling subcontractor/sample technician position the sampling equipment over the surveyed and flagged sample location.
2. The driller/sampler will collect the desired soil sample using a hand auger, split spoon, or other approved method.
3. Collect the VOC sample using the EnCore system from the collected soil sample.
4. Log the core/sample and record the data on a standard log sheet or field logbook. Conduct PID readings and record the data on the core sampling log. Photograph the soil sample, if appropriate.

## Collecting VOC Soil Samples

The following procedure describes the use of the EnCore sampling system for collecting VOC soil samples.

### Before taking a VOC Sample (Preparation)

- Hold coring body and push plunger rod down until small o-ring rests against tabs. This will assure that plunger moves freely.
- Depress locking lever on T-handle. Place coring body, plunger-end first, into open end of T-handle, aligning the two slots on the coring body with the two locking pins in the T-handle. Twist coring body clockwise to lock pins in slots. Check to ensure sampler is locked in place. Sampler is ready for use.

### Taking a VOC Sample

- Turn T-handle so that the T faces up and coring body down. This positions the plunger bottom flush with the bottom of the coring body (ensure plunger bottom is in position). Using T-handle, push sampler into soil until coring body is completely full. When full, small O-ring will be centered in T-handle viewing hole. Remove sampler from sediment or soil. Wipe excess material from coring body exterior.
- Cap coring body while it is still on T-handle. Push cap over flat area of ridge and twist to lock **cap** in place. **Cap must be seated to seal sampler.**

NOTE: The VOC sample must be collected as quickly as possible to minimize the loss of volatiles.

### Preparing EnCore Sampler for Shipment

- Remove the capped sampler by depressing locking lever on T-handle while twisting and pulling sampler from T-handle.
- Lock plunger by rotating extended plunger rod fully counter-clockwise until the **wings** rest firmly against tabs.
- Attach completed circular label (from EnCore sampler bag) to cap on coring body.

- Return full sampler to zipper bag. Seal bag and put in a sample cooler and cool with ice.
- Fill out the chain-of-custody form, and process the sample for delivery to the laboratory.
- Decontaminate sample barrel, pan or bowl, and media transfer tools before using to collect another sample.
- Collect rinse water from decontamination activities and appropriately.

NOTE: Do not leave the samples in the sun or in a warm environment for any significant length of time. Soil samples shall be cooled with ice until the sample is processed.

### Quality Control Samples

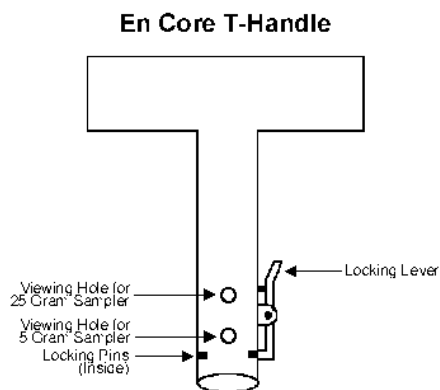
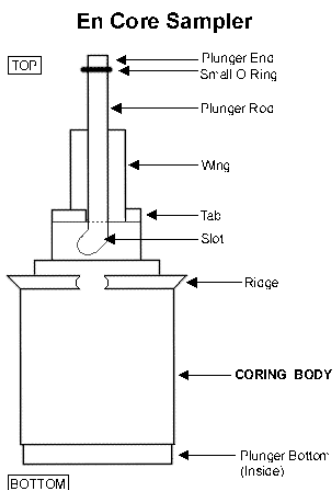
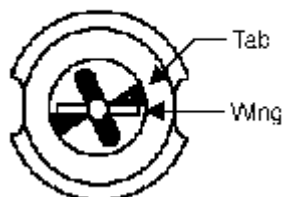
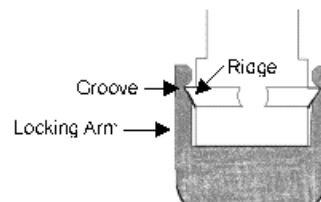
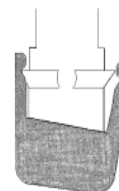
Quality control (QC) samples that are collected with soil samples include duplicates, matrix spike (MS)/matrix spike duplicates (MSDs), trip blanks, and equipment blanks. Of these, trip blanks and equipment blanks are aqueous and do not require soil volume. If a duplicate or MS/MSD sample is required at a sampling location, then a second sample aliquot shall be collected. The MS/MSD sample will be submitted to the laboratory with the original sample. Duplicates will be submitted to the laboratory as separate samples.

### Key Checks/Items

- Make sure the samples are kept at a temperature of approximately 4 degrees Celsius before and after they are processed for delivery to the laboratory.
- Determine if a QC sample will be required at a sampling location. If a QC MS/MSD or duplicate soil sample will be needed, then additional sample volume will be required. Additional sample volume is acquired by pushing another soil sample.
- Ensure all tools that may come in contact with the sample, are properly decontaminated.
- Collect rinse water from decontamination activities and manage appropriately.

## EXHIBIT 1

## Using the En Core T-Handle

*The Hoover Company, Plant No. 1, North Canton, Ohio***Locked Plunger****Sampler Correctly Capped**  
(Locking Arm Grooved Seated Over Coring Body Ridge)**Sampler Incorrectly Capped**  
(Cap Appears Crooked, Locking Arm Grooves Not Fully Seated Over Coring Body Ridge)

# Field Sampling Equipment Decontamination

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## Purpose

To provide general guidelines for decontamination of soil sampling equipment, monitoring equipment, and sample containers used in potentially contaminated environments.

## Equipment and Materials

- Demonstrated analyte-free deionized or distilled water.
- Potable water.
- Deionized or distilled water.
- Alconox (or other phosphate free detergent) and water solution.
- Methanol. DO NOT USE ACETONE.
- Large plastic pails or tubs for detergent and water, scrub brushes, squirt bottles for detergent, methanol and water, plastic bags, and sheets.
- U.S. Department of Transportation (DOT)-approved 55-gallon drum for disposal of waste.

## Procedures and Guidelines

### Sampling Equipment Decontamination

Soil, surface water, and sediment sampling equipment not to be steam cleaned (such as drilling equipment) will be decontaminated by personnel wearing disposable latex gloves or vinyl gloves using the following procedure:

1. Remove loose soil and gross contamination.
2. Rinse with potable water.
3. Wash all equipment surfaces that contacted the potentially contaminated soil or water with Alconox solution, using a brush as needed to remove particulate matter and surface films.
4. Rinse with potable water.
5. If organic contamination is suspected, rinse twice with methanol solution and air dry. DO NOT USE ACETONE.
6. Rinse with deionized or distilled water and air dry.

7. Wrap the equipment with aluminum foil, if appropriate, to prevent contamination if the equipment is to be stored or transported.
8. Collect all decontamination fluids and dispose of in a DOT-approved 55-gallon drum.

### **Monitoring Equipment Decontamination**

1. Wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe surfaces that had possible contact with contaminated materials with a paper towel wet with detergent solution; if organic contamination is suspected, wipe with a towel wet with methanol solution; and wipe three times with a towel wet with deionized or distilled water.
3. Dispose of used paper towels in a DOT-approved 55-gallon drum.

### **Sample Container Decontamination**

The outer surface of sample containers filled in the field must be decontaminated before being packed for shipment or handled by personnel without dermal hand protection.

1. Wipe container with a paper towel dampened with detergent solution after the containers have been sealed.
2. Wipe container with a paper towel dampened with potable water.
3. Dispose of used paper towels in a DOT-approved 55-gallon drum.

### **Key Checks and Items**

- Clean with solutions of detergent, methanol, and deionized or distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate sample bottles before relinquishing them to anyone.
- Document any deviations from above procedure.